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SECTION 220000 - PLUMBING

PART 1 GENERAL

1.1 SUMMARY

A. Scope of Work: Central Plant Modifications

B. Provide complete interior water, plumbing and sanitary sewer systems. "Provide" shall mean "furnish and install" when used herein. Connect to utility systems at the 5 feet building line and as shown on drawings.

C. Connect to the plumbing system, all fixtures and equipment which may be furnished by the State under another section of these specifications.

1.2 RELATED WORK SPECIFIED IN OTHER SECTIONS

A. General mechanical work as specified in Section 230300 GENERAL MECHANICAL REQUIREMENTS.

B. Exterior excavation and backfill specified in Division 02 SITE CONSTRUCTION.

C. Concrete work specified in Division 03 CONCRETE.

D. Painting work specified in Division 09 FINISHES.

E. Electrical work specified in Division 26 ELECTRICAL.

1.3 SUBMITTALS

A. Submit in accordance with Section 013300 SUBMITTAL PROCEDURES and Section 230300 GENERAL MECHANICAL REQUIREMENTS:

B. Shop Drawings: At minimum, plan view and isometric piping diagrams of plumbing system piping and equipment including connection points to the site utilities. Inverts of buried piping shall be shown on the shop drawings.

C. Color Samples: None

D. Product Data:
1. Pipe and Fittings
2. Valves
3. Specialties
4. Piping Identification
5. Valve Identification

E. Schedule: Maintenance Service Contract

F. Certificates of Conformance or Compliance:
1. Chlorination Test Results
2. Plumbing Inspection Completed

G. As-Built Drawings

H. Operations and Maintenance Manuals
I. Guarantee and Certificate

1.4 QUALITY ASSURANCE

A. Obtain and pay for all fees, permits, licenses, assessments, connection charges and inspections required for this work.

B. Accessible fixtures, other than those specified herein, require pre-bid approval to ensure compliance with the Commission on Persons with Disabilities of the State of Hawaii. No substitutions will be considered after the bid opening. Equal products are acceptable in lieu of those specified hereinafter by specific manufacturer and model number.
1. Valves: Nibco, Crane, Walworth, Dezurik, or Stockham.
2. Fixtures & Equipment: American Standard, Kohler or Eljer.
3. Drainage System Specialties: Josam, Zurn or Smith.
4. Flush Valves: Sloan or Delany.
5. Pipe Supports: Elcen, Tolco, Grinnell, Fee and Mason or Unistrut.
6. Stainless Steel Sinks: Elkay, Just, or Moen.
7. Fixture Trim: American Standard, Delta, Symmons, Sloan, Chicago, Elkay, Kohler or T&S.

C. Comply with the recommendations and requirements of the Codes and Standards listed hereinafter in addition to detailed requirements of this specification. In the event of conflicting requirements, this specification shall prevail.
1. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) PUBLICATIONS:

A53-96	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
A74-96	Cast Iron Soil Pipe and Fittings
A616-96	Standard Specification for Rail Steel Deformed and Plain Bars for Concrete Reinforcement
B88-96	Standard Specification for Seamless Copper Water Tube
B306-96	Copper Drainage Tube (DWV)
C564-95	Rubber Gaskets for Cast Iron Soil Pipe and Fittings
C150-97	Standard Specification for Portland Cement
D1785-91	Poly Vinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80 and 120
D2661-91	Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40 Plastic Drain, Waste and Vent Pipe
D2665-91b	Poly Vinyl Chloride (PVC) Plastic Drain, Waste and Vent Pipe and Fittings
D2466-90a	Poly Vinyl Chloride (PVC) Plastic Pipe Fittings (Schedule 40)
D2467-90	Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings
D2564-91	Solvent Cements For Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
D4101-94	Propylene Plastic Injection and Extrusion Materials
F656-89a	Primers For Use In Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
F1412-94	Polyolefin Pipe and Fittings For Corrosive Waste Drainage Systems

2. AMERICAN NATIONAL STANDARDS INSTITUTE PUBLICATIONS (ANSI):

B16.18-84	Cast Copper Alloy Solder-Joint Pressure Fittings
B16.22-95	Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
B16.23-92	Cast Copper Alloy Solder Joint Drainage Fittings - DWV
B16.26-88	Cast Copper Alloy Fittings for Flared Copper Tubes
B31.9-96	Building Services Piping. (Same as ASME B31.9-96)
C2-97	National Electrical Safety Code

3. CAST-IRON SOIL PIPE INSTITUTE (CISPI) PUBLICATION:

301-97	Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste and Vent Piping Applications
310-97	Coupling For Use In Connection With Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste and Vent Piping Applications
Pamphlet 100	Installation Suggestion for "No-Hub" Pipe and Fittings

4. PLUMBING AND DRAINAGE INSTITUTE (PDI) STANDARDS:

WH-201-92	Water Hammer Arrester Standard

1.5 SHOP DRAWINGS AND AS-BUILT DRAWINGS

A. Submit shop drawings and as-built drawings for the plumbing systems that conform to the general requirements in Section 230300 GENERAL MECHANICAL REQUIREMENTS.

1.6 OPERATIONS AND MAINTENANCE MANUALS

A. Submit Operations and Maintenance Manuals for all plumbing system equipment that conform to the general requirements in Section 230300 GENERAL MECHANICAL REQUIREMENTS.

1.7 GUARANTEE AND CERTIFICATE

A. Submit one year guarantee for all plumbing work in accordance with the general requirements in Section 230300 GENERAL MECHANICAL REQUIREMENTS.

PART 2 PRODUCTS

2.1 MATERIALS

A. See general requirements for materials and equipment in Section 230300 GENERAL MECHANICAL REQUIREMENTS.

2.2 EQUIPMENT

A. Requirements of manufacturer's equipment that is a component of a system provided under this work are included with the system's specifications hereinafter. Provide capacities and characteristics of the equipment shall be as indicated. See electrical drawings for all power wiring and disconnecting devices to all equipment requiring electrical power furnished under this Section.

2.3 PIPE AND FITTINGS

A. Drainage, Waste and Vent Piping Below Grade: Service weight cast-iron soil pipe and fittings, conforming to ASTM A74, "Standard Specification for Cast Iron Soil Pipe and Fittings," no-hub cast iron soil pipe conforming to CISPI 301, "Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste and Vent

Piping Applications," with cast iron mechanical couplings, stainless steel bolts and nuts, and neoprene gaskets or heavy duty stainless bands with 4 or more adjusting screws. Provide MG coupling, Husky Series 4000 Anaheim Foundry Company or approved equal.

B. Drain, Waste and Vent Piping Above Grade: Service weight cast-iron soil pipe and fittings, conforming to ASTM A74, "Standard Specification for Cast Iron Soil Pipe and Fittings," no-hub cast iron soil pipe conforming to CISPI 301, "Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste and Vent Piping Applications," with stainless steel bands and neoprene gaskets.

C. Potable Water Piping: Type "L" hard-drawn copper tube, conforming to ASTM B88, "Standard Specification for Seamless Copper Water Tube," with soldered (95-5) joint wrought copper pressure fittings conforming to ANSI 16.22. Use long radius elbows wherever possible. Use Type "K" hard-drawn copper tube with brazing alloy on joints and pipes below grade.

2.4 VALVES

A. Ball Valves 3 Inches and Smaller: 600 psi W.O.G., bronze, two piece body, 316 stainless steel ball, reinforced TFE seat and seals, full port, threaded ends, 316 stainless steel stem, lever handle with integral stop. Provide NIBCO T-585-70-66 or approved equal.

B. Check Valves 1-1/2 Inches and Smaller: 125-lb. S.W.P., bronze body and trim, swing check valve, bronze disc, bronze hinge pin, Buna-N resilient seat, threaded ends. Provide NIBCO T-413 or approved equal.

C. Check Valves 2 Inches and Larger: 125-lb. S.W.P., double door check valve, steel or cast iron body, aluminum bronze doors, stainless steel spring and pins, Buna-N resilient seat, non-slam closure, lug body style. Provide APCO 9000-L, NIBCO or approved equal.

D. Plug Valves 2 Inches and Smaller: 150-lb. S.W.P., bronze body and plug, screwed ends. Provide Dezurik Figure 120, Val-matic or approved equal.

2.5 PLUMBING SYSTEM SPECIALTIES

A. Cleanouts:
1. Cleanout - CO: Provide Smith No. 4470, Josam or approved equal, bronze countersunk plug.
2. Cleanout to Grade - COTG: Provide Smith No. 4250, Josam or approved equal, cast iron body and scoriated top, installed with concrete collar, flush with grade.
3. Floor Cleanout - FCO: Provide Smith No. 4105, Josam or approved equal cast iron cleanout with round heavy duty scoriated nickel-bronze top, ABS plug and flashing flange.

B. Vent Flashing: Four pounds per square foot sheet lead or factory fabricated flashing with rubber gaskets designed specifically for sheet metal roofing systems.

C. P-Traps Installed Below Floor: Deep-seal cast-iron p-trap.

D. Pressure Reducing Valves - PRV: Provide bronze body water pressure reducing valves for domestic water supply systems conforming to American Society of Sanitary Engineering (ASSE) 1003. Provide Watts Series U5B, 223, Febco, Conbraco or approved equal with strainer. Provide additional pressure reducing valve in parallel to accommodate stable water flow over the entire range of flow demand. Provide a

permanently installed downstream pressure gauge for each PRV to allow adjusting of the setpoint.

E. Water Meter: Provide as specified in Section 236410 CENTRAL REFRIGERATION EQUIPMENT.

2.6 PRESSURE GAUGES

A. Pressure gauges shall be Grade A, accurate within 1 percent of full scale, phosphor bronze Bourdon tube, spring type, with 4-1/2-inch diameter dials unless otherwise indicated, with recalibrating screws. Socket shall be 1/4 inch NPT forged brass, bottom outlet. Gauges shall have plain cast aluminum cases with screwed rings finished in black enamel or chromed and shall be installed with necessary piping, including heavy duty needle valve.

B. Pressure gauges ranges shall be such that the position of the pointer during normal operation will be 50 percent of dial range.

2.7 REDUCED PRESSURE BACKFLOW PREVENTER

A. Reduced pressure backflow preventer shall be in accordance with ASSE 1013 and City and County of Honolulu Board of Water Supply listed and approved. Provide bronze body, with bronze strainer, quarter-turn ball valves and test cocks. Provide funnel for capturing drips and drain lines to closest floor drain or day light. Watts Model RPZ Series 909, Febco, Conbraco or approved equal.

PART 3 EXECUTION

3.1 PREPARATION

A. Determine the exact route of each pipe and check for interferences with the building structure, foundation, electrical work and other work in the area. Make offsets and changes in direction required to maintain proper head room and pitch or to accommodate the structure and the work of other trades. Furnish other trades with information to properly locate and size openings in the structure required for this work. Furnish anchor bolts, sleeves, inserts and supports required for this work. Coordinate and schedule plumbing work with Contractor to allow construction to proceed without delays. Install rough-in piping for fixtures, equipment and specialties according to the schedule when the structure is ready (e.g. hose bibbs located in CMU walls before walls are grouted).

3.2 INSTALLATION AND REQUIREMENTS

A. Provide guard or insulation around high-temperature equipment and materials to protect personnel. When exposed to weather, provide a weather protected enclosure around electrical equipment, controls and other items that are not satisfactorily protected. All required demolition including saw cutting and chipping of concrete and masonry to remove or install fixtures and piping shall be provided as well as patching, repair and painting at no additional cost to the State.

3.3 CUTTING AND PATCHING

A. Cut all holes necessary for installation of work under this Section.

B. Patching of all holes, etc., will be done under other sections of specification. Patch any holes cut unnecessarily.

3.4 ACCESS TO EQUIPMENT

A. Install all control devices, specialties, valves and related items to provide easy access for operation, inspection, repair and maintenance. If these items are concealed behind walls or ceilings of non-removable type construction, provide access panels of proper size for easy access at no additional cost to the State.

3.5 EQUIPMENT INSTALLATION

A. Install equipment, piping and appurtenances in accordance with the requirements of Section 230300 GENERAL MECHANICAL REQUIREMENTS. Provide equipment accessories necessary for proper operation and support.

3.6 PIPING INSTALLATION

A. Conform to the requirements of the current Uniform Plumbing Code as adopted by the City and County of Honolulu. Inspect all pipe inside and outside. Remove interior obstructions and ream out pipe ends. Tool markings on polished fittings are not acceptable. Cut pipe accurately so that it can be worked into place without springing or forcing. Install pipes parallel to the wall of the structure and plumb. Make changes in direction with fittings. Bushings are not permitted. Install valves with stems above horizontal. Provide proper support and adequate provisions for expansion, contraction, slope and anchorage. Provide dielectric unions where copper tubing connects to steel pipe. Wrap pipe or tubing with 1/4-inch thick felt, secure with tape, where it contacts other materials. Have piping tested, inspected and approved before it is furred in, buried or otherwise hidden. Provide standard weight galvanized steel pipe sleeves where pipes pass through structure, sufficiently large to provide 1/4-inch minimum clearance around pipe. Caulk watertight around pipes passing through sleeves. Wrap pipe with polyethylene tape where it passes through sleeve and when it contacts concrete or masonry. Grout with fireproof material around all pipe penetrations through slabs and walls full length of penetrations. Where pipes pass through fire walls or floors, seal both ends of sleeve with Underwriters Laboratories listed thermal barrier material to maintain fire rating. Provide chrome-plated brass escutcheons, set tight on the pipe and to the wall where pipes are exposed in finished areas. Provide clamping collar or membrane flange where pipe or drains penetrate waterproof membrane. Perform all welding using qualified welders in accordance with American National Standards Institute's Code B31.9 and American Welding Society Standard B3.0. Insulate piping specified in accordance with the manufacturer's recommendations.

3.7 PIPING SYSTEM SUPPORTS

A. Pipe Supports: For above ground piping, see details on drawings. Support copper pipe at maximum spacing of 4 feet for pipes 1-1/2-inch and smaller, 7 feet for pipes 2-inch through 4-inch.

B. Pipe Hangers: Steel clevis hanger with adjustable hanger rod; 3/8-inch for pipe 2-inch and smaller. 2-inch for pipe 2-1/2-inch through 3-1/2-inch and 5/8-inch for pipe 4-inch and larger. For copper pipes, provide copper hangers, plastic coated steel or other commonly used protective surfaces to prevent contact of dissimilar materials used for the piping and

hangers. Groups of lines shall be supported as detailed on drawings. Provide trapeze type hangers for groups of pipes routed at the same elevation. Hanger rods shall not be supported from other pipe and conduit hangers or supports unless specifically designed for this application.

C. Supplemental Steel: Provide supplemental structural steel piping supports as required to support piping from structure. Supplemental structural and supporting steel shall be hot-dipped after fabrication and, if exposed, painted with a final coat to match adjacent area.

3.8 DRAINAGE, WASTE AND VENT PIPE SYSTEMS

A. Coordinate point of connection locations and material compatibility with the site utilities contractor's work and schedule. Slope drain lines at 1/4-inch per foot unless otherwise indicated. Install hub cast-iron pipe in accordance with CISPI & Fittings Handbook 1990. Install no-hub cast-iron pipe in accordance with CISPI pamphlet 301. Provide cast-iron and neoprene gasketed hub coupling below grade. Above grade MG stainless steel clamps and cast-iron no-hub couplings shall be installed in accordance with manufacturer's written instructions. On roof vents and where other drains occur above the ground floor, provide clamping device with drain. Provide a four-pound lead flashing sheet extending eight (8) inches out around drain body for flat roof areas and secure with clamp device or factory fabricated flashing with rubber gasket designed for sheet metal roofs. Coordinate point of connections, locations and materials, with site utilities.

3.9 WATER PIPING SYSTEM

A. Coordinate point of connection locations and material compatibility with the site utilities contractor's work and schedule. Secure each water line where it penetrates partitions to serve fixtures, and similar items. Wrap all lines passing through concrete with polyethylene tape. Install unions or flanges at all valves, equipment and system specialties. Install dielectric unions at connections of copper and ferrous pipes. Coordinate point of connections, locations and materials, with site utilities.

3.10 PRESSURE GAUGES

A. Install pressure gauges where indicated and at supply and return chilled water connection at each cooling coil.

3.11 DIELECTRIC CONNECTIONS

A. Copper pipe shall be insulated from direct contact with ferrous piping connections by approved insulating (dielectric) unions or couplings or flanges.

3.12 FIELD QUALITY CONTROL

A. Test plumbing systems in accordance with the Uniform Plumbing Code. Perform tests in the presence of, and to the satisfaction of inspectors having jurisdiction over the work. Ask for final inspection by the Engineer after all tests, adjustments and balancing have been performed.
   1. Test drainage systems in accordance with Section 318 of the Plumbing Code.
   2. Hydrostatically test the domestic water piping system at 100 psi. Inspect the entire system while under pressure and correct all deficiencies.
   3. Test equipment to demonstrate its operations and compliance with the specification.

B. All drainage piping systems which show signs of obstructed flow, no flow or slow flow shall

be thoroughly snaked until all obstructions are cleared and water drains freely.

3.13 TESTING AND INSPECTION

A. Contractor shall furnish all equipment for tests and any required retests and pay for all cost of repairing any damage resulting from such tests. Contractor shall repair and adjust systems until they are approved. Tests shall be performed in presence of, and to satisfaction of, inspector of official agency involved.

B. Defective Work: If inspection or test shows defects, such defective work or material shall be replaced and inspection and tests repeated. Repairs to piping shall be made with new material. No caulking of screwed joints or holes will be accepted.

C. Protection to Fixtures, Materials, and Equipment: Pipe openings shall be closed with caps or plugs during installation. Fixtures and equipment shall be tightly covered and protected against dirt, water, and chemical or mechanical injury. Upon completion of all work, fixtures, materials, and equipment shall be thoroughly cleaned, repainted as required, adjusted, and operated.

D. Removal and Capping of existing plumbing lines as required is included in this Section to isolate existing pipes.

E. Chlorination: Domestic water lines shall be sterilized with chlorine before acceptance of work. Sterilize water system for 24 hours with 100 ppm chlorine introduced into the lines in an approved manner. Operate all valves during contact period. Flush system until chlorine is less than 0.2 ppm. All valves in lines being sterilized shall be opened and closed several times during contact period. Certificate shall be furnished to Engineer evidencing proper performance of sterilization.

3.14 ADJUST AND CLEAN

A. Clean-up work areas and fixtures: Adjust system for proper operation, ready for use. Touch up with matching paint all damaged factory finishes. Provide valve tags, and a list which includes the type of valve tag, size, location, and area served. Clean diaphragms for the flush valves per the manufacturer's recommendations. Bleed all air from lines.

3.15 PAINTING AND IDENTIFYING OF PIPING

A. General:
   1. All non-factory finished (i.e. finish painted) items furnished under this section are to be painted including exposed piping, insulation and fittings. See Section 099000 PAINTING. Do not paint over name plates or other identifying labels.
   2. Paint exposed black iron work including pipe, fittings, iron body valves, pipe hangers, etc., with two coats of zinc rich paint and finish coat to match adjacent surfaces.

B. Identification of Piping: Provide piping identification for all above ground plumbing system piping in accordance with the requirements of Section 230300 GENERAL MECHANICAL REQUIREMENTS.

C. Identification of Valves: Provide valve tags for all plumbing system valves in accordance with the requirements of Section 230300 GENERAL MECHANICAL REQUIREMENTS.

D. Identification of Equipment: Provide equipment tags in accordance with the requirements of Section 230300 GENERAL MECHANICAL REQUIREMENTS. Plumbing fixtures and underground equipment do not require equipment tags.

3.16 INSTRUCTIONS

A. Provide instructions to State personnel for plumbing system operation in accordance with the requirements of Section 230300 GENERAL MECHANICAL REQUIREMENTS. Upon completion of the work and at a time designated, the services of one or more qualified personnel shall be provided by the Contractor for a period of not less than eight (8) hours to instruct the representatives of the State in the operation and maintenance of the air conditioning system. These field instructions shall cover all the items contained in the bound instructions.

3.17 ONE YEAR MAINTENANCE SERVICE CONTRACT

A. Provide maintenance service for all plumbing system components as specified in and in accordance with the requirements and schedule of Section 230300 GENERAL MECHANICAL REQUIREMENTS.

3.18 OPERATION AND MAINTENANCE MANUAL

A. Shall be provided as specified in Section 230300 GENERAL MECHANICAL REQUIREMENTS.

END OF SECTION

SECTION 220548 - MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL

PART 1 GENERAL

1.1 SUMMARY

A. Scope of Work: Central Plant Modification

B. This section covers the furnishing, fabrication, delivery and installation of the sound, vibration and seismic control equipment for the air conditioning, ventilation and plumbing systems complete, including but not limited to the following:
   1. Vibration isolators
   2. Flexible connections for piping
   3. Flexible duct connections
   4. Seismic control equipment
   5. Manufacturer's literature, shop drawings and record drawings.

1.2 RELATED WORK SPECIFIED IN OTHER SECTIONS

A. Mechanical work as specified in Section 230300 GENERAL MECHANICAL REQUIREMENTS unless specified otherwise in other sections of Division 23 HEATING, VENTILATING, AND AIR CONDITIONING.

B. Central refrigeration equipment specified in SECTION 236410 CENTRAL REFRIGERATION EQUIPMENT.

E. Chilled water and condenser water piping specified in SECTION 232113 CHILLED WATER PIPING.

1.3 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.
   1. AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)
      AISC S342L — Load and Resistance Factor Design Specification for Structural Steel Buildings
   2. AIR-CONDITIONING AND REFRIGERATION INSTITUTE (ARI)
      ARI 575 — Measuring Machinery Sound Within an Equipment pace
   3. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
      ASTM A 36/A 36M — Carbon Structural Steel
      ASTM A 123 — Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
      ASTM A 653/A 653M — Steel Sheet Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanized) by the Hot-Dip Process
      ASTM D 471 — Rubber Property - Effect of Liquids
      ASTM D 2240 — Rubber Property - Durometer Hardness
      ASTM E 84 — Surface Burning Characteristics of Building Materials
   4. AMERICAN WELDING SOCIETY, INC. (AWS)
      AWS D1.1 — Structural Welding Code Steel
   5. SHEET METAL & AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION, INC. (SMACNA)

SMACNA APIDC	Accepted Industry Practice for Industrial Duct Construction
SMACNA SRM	Seismic Restraint Manual Guidelines for Mechanical Systems

1.4 DEFINITIONS

A. Decibels dB: Measure of sound level. Decibels are referenced to either 20 uPa for sound pressure levels or one pW for sound power levels. dBA is the overall "A" weighted sound level.

B. Machinery: The vibration or noise producing equipment that must be isolated.

C. Manufacturer: The fabricator or supplier of vibration-isolation or seismic-protection materials and equipment. For mechanical equipment and machinery the term machinery manufacturer will be used.

D. Micropascal uPa: 10 to the minus 6 power newtons per square meter.

E. Picowatt pW: 10 to the minus 12 power watts.

1.5 SYSTEM DESCRIPTION

A. Machinery Vibration Criteria: Provide vibration isolators for mechanical and electrical machinery and associated piping and ductwork as indicated, to minimize transmission of vibrations and structure borne noise to the building structure or spaces or from the building structure to the machinery. Provide vibration isolator type and static deflection in accordance with the following:

TABLE 1A

Vibration Isolator Types and Minimum Static Deflection (MSD, inches)

Equipment	Type	MSD
Centrifugal Chiller	SX	1.0
Cooling Tower	SX	1.0
Heat Pump	SX	1.0

NOTES: (1) Equipment Vibration Isolation Schedule Designations (Hyphenated designations are combinations of the following:)

H - Suspension Spring isolators (suspended equipment and piping). Where required, provide with adjustable preloading devices.

NM - Neoprene mounts.

NP - Neoprene isolation pads.

SX - Freestanding spring isolators with adjustable cushioned vertical stops and cushioned horizontal stops (floor-mounted equipment).

B. Basic Criteria: For each piece of machinery in the human work environment, do not exceed the maximum airborne sound levels 84 dB A-weighted scale, continuous or intermittent, or 140 dB peak sound pressure-level, impact or impulse, noise.

C. Seismic Protection Criteria: Use a Horizontal Force Factor minimum 60 percent of the equipment weight considered passing through the equipment center of gravity in any horizontal direction. Unless vibration isolation is required to protect equipment against unacceptable structure transmitted noise or vibration, protect the structure or equipment from earthquakes by rigid structurally sound attachment to the load-supporting structure. Protect each piece of vibration-isolated equipment with protected spring isolators or separate seismic restraint devices. Determine by calculations the number and size of seismic restraints needed for each equipment, duct or pipe. Verify seismic restraint vendor's calculations by a registered professional engineer. Provide seismic snubbers and protected spring isolators rated in three principle axes. Verify ratings by independent laboratory testing.

D. Welding: AWS D1.1.

1.6 SUBMITTALS

A. Submit in accordance with Section 013300 SUBMITTAL PROCEDURES and Division 23 HEATING, VENTILATING, AND AIR CONDITIONING.

B. Manufacturer's Catalog Data:
1. Isolators
2. Flexible connectors
3. Flexible duct connectors
4. Pipe guides
5. Machinery manufacturer's sound data

C. Spring Isolator Data: For each type and size of spring isolator, submit the spring outside diameter, deflection, operating spring height, unloaded spring height, solid spring height, the ratio of the outside diameter to the operating spring height, the load to deflection ratio of the springs, and weight and sizes of structural steel members.

D. Machinery Manufacturer's Sound Data: For each piece of indicated machinery to be vibration isolated, the calculated sound power test data or sound pressure test data as levels in dB in the eight octave bands between 63 and 8,000 Hz. Refer sound power levels to one pW and sound pressure levels to 20 uPa. Submit the overall "A" weighted scale sound pressure level in dB. Submit the standard test procedure used to obtain the sound power or pressure data for the applicable vibration isolation equipment size.

E. Machinery: For each item of machinery, compare spring static deflections with the specified minimum static deflection, to show that the calculated spring static deflections are not less than the minimum static deflections specified. Rated spring static deflections are not acceptable in lieu of calculated spring static deflections. When seismic protection is required, substantiating calculations are required.

F. Machinery Over 300 Pounds: For machinery items over 300 pounds, provide calculations for shear, pull-up, primary overturning, and secondary overturning.

G. Instructions:
1. Vibration and noise isolation components
2. Seismic protection components

H. Seismic Protection Rating: Submit in three principal axes certified by an independent laboratory or analyzed by an independent licensed structural engineer.

1.7 QUALITY ASSURANCE

A. Vibration Isolator Procurement: For each piece of machinery to be isolated from vibration, supply the vibration isolators and other associated materials and equipment as a coordinated package by a single manufacturer or by the machinery manufacturer. Select isolators that provide uniform deflection even when machinery weight is not evenly distributed. This requirement does not include the flexible connectors or the hangers for the associated piping and ductwork.

B. Unitized Machinery Assemblies: Mounting of unitized assemblies directly on vibration isolation springs is acceptable if machinery manufacturer certifies that the end supports of the assemblies have been designed for such installation.

PART 2 PRODUCTS

2.1 CORROSION PROTECTION FOR STEEL PARTS

A. ASTM A 123, ASTM A 653 hot-dipped galvanized, or equivalent manufacturer standard coatings. Where steel parts are exposed to the weather, provide galvanized coating of at least 2 ounces of zinc per square foot of surface. Coat springs with neoprene.

2.2 NEOPRENE

A. ASTM D 471 and ASTM D 2240, Grade Durometer 40, 50, or 60, and oil resistant.

2.3 SPRING ISOLATORS

A. Provide seismic restraint type spring isolators that are adjustable and laterally stable with free-standing springs of horizontal stiffness at minimum 80 percent of the vertical (axial) stiffness. Isolator housing shall be galvanized. For machine-attached and floor-attached restraining elements, separate from metal-to-metal contact by neoprene cushions 1/8 inch thick minimum. Provide neoprene acoustic friction pads at least 1/4 inch thick. Isolator housing shall be galvanized. Spring isolators shall be as manufactured by Mason Industries, Inc., M.W. Sausse, Amberbooth, Caldyn or approved equal.

B. Springs: Provide springs with base and compression plates, to keep spring ends parallel during and after deflection to operating height. Provide outside coil diameters at least 0.8 of the operating height. At operating height, springs shall have additional travel to complete (solid) compression equal to at least 50 percent of the operating deflection. Springs shall be galvanized or neoprene coated.

C. Mounting and Adjustment: Provide base and compression plates with mounting holes or threaded fittings. Bolt leveling adjustment bolts to machinery or base.

2.4 FLEXIBLE CONNECTORS FOR PIPING

A. Straight or elbow flexible connectors rated for temperatures, pressures, and fluids to be conveyed. Provide flexible connectors with the strength 4 times operating pressure at highest system operating temperature. Provide elbow flexible connectors with a permanently set angle.
   1. Elastomeric Flexible Connectors: Flexible neoprene connectors with Hypalon cover shall

be provided in all water piping connections to pumps and air handling units where pipe is greater than 2-inch nominal diameter. Connectors shall be of neoprene, single sphere, with ductile iron Class 150 flanged connections. Flanged assemblies shall be equipped with limit bolt to restrict maximum travel and resist pressure thrusts. Connectors shall have a minimum rating of 225 psi at 170 degrees F operating temperature. All materials shall be suitable for use in chilled water systems and outdoor environments. Connectors shall be Mason Industries, Inc., Type MFNC, Mercer Rubber or approved equal.

2. Flexible Hoses: Metallic braided bronze hoses shall be provided in all chilled water piping to the pumps, air handling units and fan coil units where pipe is 2-inch or less nominal diameter. Hoses shall be Mercer BBF, Mason Industries, Inc. or equal. Provide soldered or threaded ends. Lengths shall be 6 times the nominal diameter with a maximum of 36 inches. Hoses shall be installed on equipment side of shut-off valves and horizontally wherever possible.

2.5 SEISMIC PROTECTION COMPONENTS FOR PIPING AND DUCTWORK

A. Provide in accordance with SMACNA SRM and the National Uniform Seismic Installation Guidelines (NUSIG).

PART 3 EXECUTION

3.1 INSTALLATION

A. Vibration and Noise Isolation Components: Install vibration and noise isolation materials and equipment as indicated and in accordance with machinery manufacturer's instructions.

B. Suspension Vibration Isolators: Provide suspension isolation hangers for suspended equipment as indicated and as specified.

C. Flexible Pipe and Duct Connectors: Install flexible connectors in accordance with the manufacturer's instructions. When liquid pulsation dampening is required, flexible connectors with spherical configuration may be used. Provide restraints for pipe connectors at pumps to prevent connector failure upon pump startup.

D. Machinery: Provide vibration isolators, flexible connectors in accordance with manufacturer's recommendations. Machinery with spring isolators or protected spring isolators shall rock or move freely within limits of stops or seismic snubber restraints.
   1. Stability: Isolators shall be stable during starting and stopping of machinery without traverse and eccentric movement of machinery that would damage or adversely affect the machinery or attachments.
   2. Lateral Motion: The installed vibration isolation system for each piece of floor or ceiling mounted machinery shall have a maximum lateral motion under machinery start up and shut down conditions of not more than 1/4 inch. Restrain motions in excess by approved spring mountings.
   3. Unbalanced Machinery: Provide foundation suspension systems specifically designed to resist horizontal forces for machinery with large unbalanced horizontal forces. Vibration isolator systems shall conform to the machinery manufacturer's recommendations.

E. Piping and High Pressure Ductwork: Provide vibration isolation for piping and high pressure ductwork with over 6 inches water column. The isolator deflections shall be equal to or greater than the static deflection of the vibration isolators provided for the connected machinery as follows:
   1. High Pressure Ductwork: For a distance of 50 feet from fans, exhausters and blowers.

2. Piping Connected to Vibration Isolated Machinery: For a distance of 50 feet or 50 pipe diameters, whichever is greater.
3. Chilled Water Piping: For risers from pumps and for the first 20 feet of the branch connection of the main supply and return piping at each floor.

F. Pipe Hanger and Support Installation:
1. Pipe Hangers: Provide eye-bolts or swivel joints for pipe hangers to permit pipe thermal or mechanical movement without angular misalignment of hanger vibration isolator.
2. Pipe Risers: Provide pipe riser supports with bearing plates and two layers of 1/4 inch thick ribbed or waffled neoprene pad loaded to not more than 50 psi. Separate isolation pads with 1/4 inch steel plate. Weld pipe riser clamps at anchor points to the pipe and to pairs of vertical acoustical pipe anchor mountings which shall be rigidly fastened to the steel framing.
3. Supports at Base of Pipe Risers: Piping isolation supports at the base of risers shall be two layers of 1/2 inch thick heavy-duty neoprene pad separated by 1/4 inch thick steel plate. Use bearing plates sized to provide a pad loading of not more than 500 psi. Weld the stanchion between the pipe and isolation support to the pipe and weld or bolt to the isolation support. Bolt isolation support to the floor slab with resilient sleeves and washers. Where supplementary steel is required to support piping, provide a maximum deflection of 0.08 inches at the mid-span of this steel under the load. Rigidly support piping from the supplementary steel with the supplementary steel isolated from the building structure with isolators.

G. High Pressure Ductwork Hanger and Support Installation: Provide ductwork with vibration isolation hangers and supports where required or indicated. Connect ductwork to equipment with flexible duct connectors. Segment ductwork with flexible duct connectors.
1. Duct Risers: Provide duct riser supports within shafts with suitable bearing plates and two layers of 1/4 inch thick ribbed or waffled neoprene pad loaded to not more than 50 psi. Separate isolation pads with 1/4 inch steel plate.
2. Supports at Base of Duct Risers: For duct isolation supports at the base of risers, provide two layers of 1/2 inch thick heavy-duty neoprene pad separated by 1/4 inch thick steel plate. Use bearing plates sized to provide a pad loading of not more than 500 psi. Weld the stanchion between the duct and isolation support to the pipe, and weld or bolt to the isolation support. Bolt isolation support to the floor slab with resilient sleeves and washers. Where supplementary steel is required to support ducts, provide a maximum deflection of 1/4 inch at the midspan of this steel under the supported load. Rigidly support duct from the supplementary steel and the supplementary steel isolators.

H. Equipment Room Sound Isolation: Do not allow direct contact between pipe or ducts and walls, floor slabs, roofs, ceilings or partitions of equipment rooms.
1. Pipe Penetrations: Provide galvanized Schedule 40 pipe sleeves and tightly pack annular space between sleeves and pipe with insulation having a flame spread rating not more than 25 and a smoke developed rating not more than 50 when tested in accordance with ASTM E 84, maximum effective temperature 1000 degrees F, bulk density 6 pounds/cu. ft. minimum. Provide uninsulated pipe with a one inch thick mineral fiber sleeve the full length of the penetration and seal each end with an interior non-hardening compound. Provide sealant and mineral-fiber sleeve of a flame spread rating not more than 25 and a smoke developed rating not more than 50 when tested in accordance with ASTM E 84.
2. Duct Penetrations: Pack openings around ducts with mineral fiber insulation the full length of the penetration having a flame spread rating not more than 25 and a smoke developed rating not more than 50 when tested in accordance with ASTM E 84. At each end of duct opening provide sealing collars and seal with an interior non-hardening compound.

I. Seismic Restraints for Piping and Ductwork: Provide seismic restraints in accordance with SMACNA SRM and the National Uniform Seismic Installation Guidelines (NUSIG).

J. Systems Not To Be Vibration Isolated: Do not provide vibration isolation for electrical raceways and conduits or for fire protection (see Division 21 Section 211313 AUTOMATIC WET-PIPE FIRE SPRINKLERS), storm, sanitary, and domestic water piping systems which do not include pumps or other vibrating, rotating, or pulsating equipment including control and pressure reducing valves.

3.2 FIELD QUALITY CONTROL

A. Notify State 14 days prior to machinery testing.
   1. Field Inspections: Prior to initial operation, inspect the vibration isolators for conformance to drawings, specifications, and manufacturer's data and instructions. Check for vibration and noise transmission through connections, piping, ductwork, foundations, and walls. Check connector alignment before and after filling of system and during operation. Correct misalignment without damage to connector and in accordance with manufacturer's recommendations.
   2. Spring Isolator Inspection: After installation of spring isolators or protected spring isolators, and seismic restraint devices, the machinery shall rock freely on its spring isolators within limits of stops or seismic restraint devices. Eliminate or correct interferences.

END OF SECTION

DIVISION 23 – HEATING, VENTILATING, AND AIR CONDITIONING

SECTION 23 03 00 - GENERAL MECHANICAL REQUIREMENTS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Scope of Work: Central Plant Modifications

B. These general mechanical requirements apply to all sections of Division 23 HEATING, VENTILATING, AND AIR CONDITIONING of this project specifications, unless specified otherwise in the individual sections.

C. "Provide" shall mean "furnish and install."

1.2 QUALITY ASSURANCE

A. The Contractor shall furnish all labor, materials, tools and equipment and perform all work and services necessary for complete and properly operated mechanical systems, as shown on the drawings and as specified, in accordance with provisions of the Contract Documents and completely coordinate his work with that of all other trades.

B. The Contractor shall completely examine the Contract Documents and shall report to the Contracting Officer any error, inconsistency or omission he discovers. Bidders are cautioned to review the Technical Specifications carefully and thoroughly. The submittal of a bid shall be considered an acceptance of the specifications as published. Protests concerning the Technical Specifications lodged after bid opening shall not be considered.

C. The Contractor shall visit the site and examine the conditions affecting his work before submitting his proposal. The submission of the proposal shall be considered evidence that the Contractor has visited the site and no extra payments will be allowed to the Contractor on account of extra work made necessary by his failure to visit the site.

D. Provide all supplementary or miscellaneous items, hangers, supports, details, appurtenances and devices incidental to or necessary for a sound, secure and complete mechanical system where work required is not specifically indicated.

E. Drawings and specifications shall be taken together. Provide work specified or stated in one or the other document as though mentioned in both documents.

F. Substitution of another manufacturer's product for materials or equipment specified and for items with "approved equal" after the brand name requires approval in accordance with the GENERAL CONDITIONS. Substitutions will not be considered unless specifically approved by the State as an exception. The State reserves the right to make the decision unilaterally. Equal products are acceptable in lieu of those specified hereinafter by specific manufacturer and model number if approved.

G. The Contractor shall warrant that all materials and equipment, furnished under this Contract, will be new and that all work will be of good quality, free from faults and defects, in conformance with the Contract Documents for a guarantee period of two years.

H. The Contractor shall maintain at the site, a minimum of one (1) copy of all Drawings, Specifications, Addenda, approved Shop Drawings, Change Orders and other modifications, in good order and marked to record all changes made during construction. These shall be made available to the Contracting Officer upon request.

I. The Contractor, at all times, shall keep the premises free from accumulation of waste materials or rubbish caused by his operations. Upon completion of the work, the Contractor shall remove all his waste materials and rubbish from and about the project, as well as all his tools, construction equipment, machinery and surplus materials and shall clean all new equipment, materials, items and accessories.

J. The Contractor shall give the Contracting Officer timely notice of its readiness for testing any work, including the scheduling of agencies with the jurisdiction over the work, test equipment and personnel, and all other data arrangements for the State to observe the testing. The Contractor shall bear all cost of such tests.

K. Workmanship and Materials:
1. Workmanship shall be of the best quality and none but competent mechanical workers skilled in their trades and thoroughly familiar with the work involved shall be employed. The Contractor shall furnish the services of an experienced superintendent, who will be constantly in charge of the work, until the project is completed and accepted.
2. Reference to standards are intended to be the latest revision of the standard specified.
3. Unless otherwise specified later in this section, each article of its kind shall be the standard product of a single manufacturer.
4. Whenever the words “or approved equal” or other words of similar intent or meaning are used, implying that judgment is to be exercised, it is understood that it is the judgment of the Contracting Officer.
5. The State shall have the right to accept or reject any material, equipment and/or workmanship and determine when the Contractor has complied with the requirements specified in this section.
6. All manufactured materials shall be delivered and stored in their original containers. Equipment shall be clearly marked or stamped with the manufacturer’s name and rating. Equipment and materials shall be carefully handled, properly stored and adequately protected to prevent damage before and during installation, in accordance with the manufacturer’s recommendations and as approved by the Contracting Officer. Damaged or defective items, in the opinion of the Contracting Officer, shall be replaced.

L. The Contracting Officer shall have the right to accept or reject materials, equipment and/or workmanship and determine when the Contractor has complied with the contract documents.

1.3 CONTRACT DRAWINGS

A. Contract drawings are essentially diagrammatic, indicating general layout and approximate locations toward establishing the scope for uniform estimating basis for all bidders. They are not intended to be detailed construction working drawings. Equipment, ductwork and piping arrangements shall fit into space allotted and shall allow adequate clearances for servicing and maintenance. Reasonable modifications to indicated locations and arrangement to suit job conditions shall not constitute basis for requesting additional funds from the State.

B. Because of the small scale of drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. Contractor shall carefully investigate structural and finish conditions affecting his work and arrange such work accordingly, furnishing such fittings, traps, valves, ductwork, piping, supports, and accessories as may be required to meet such conditions.

C. Verification of Dimensions: The Contractor shall be responsible for the coordination and proper relation of his work to the building structure and to the work of all trades. The Contractor shall visit the premises and thoroughly familiarize himself with all details of the work and working conditions, to verify all dimensions in the field, and to advise the Contracting Officer of any discrepancy before performing any work.

1.4 SUBMITTALS

A. Submit in accordance with Section 013300 SUBMITTAL PROCEDURES.

B. Additional submittal requirements are specified in each mechanical section with the general requirements for submittals specified in this section and apply to all mechanical sections.

C. Within 20 days after award of contract and before installation of any materials or equipment is begun, Contractor shall submit to the State for approval a complete list of materials and equipment together with names and addresses of manufacturers and local Hawaii based manufacturer's representatives, catalog numbers, and trade names; and, annotated descriptive data showing the specific model, type, and size of each item the Contractor proposes to furnish. No consideration shall be given to partial lists submitted from time to time. Prepare working drawings on sheets not smaller than 24 inches by 36 inches, and include data essential to the proper installation of the system. Do not commence work until the design of the system and the various components have been approved.

D. Approval of materials and equipment will be based on manufacturer's published rating. Any materials and equipment which are not in accordance with these specifications may be rejected. Contractor shall not order materials and equipment without the submittal first being approved. Ordering of material and equipment without prior approval may be rejected by the State.

E. Prior to start of any field work, required copies of to scale shop drawings of equipment, ductwork, piping and controls shall be submitted for review. No work shall be started without approval from the State. Where apparatus and equipment have been indicated on the contract drawings, dimensions have been taken from typical equipment of the class indicated. The shop drawings shall show the details of construction and installation of the particular equipment being furnished. The shop drawings shall be fully dimensioned to show the equipment, materials and connections fit the space provided.
   1. Contractor shall check the submittals and shop drawings and certify they are correct and in compliance with the contract drawings and specifications.
   2. Review of shop drawings by the State's representatives is confined to arrangement of equipment and fixtures only and does not relieve the Contractor from responsibility for proper fit, performance and construction. Any deviation from the Contract drawings and specifications shall be clearly noted on the shop drawings. Since manufacturing methods vary, reasonable variations from the Contract Documents are acceptable; however, performance and material requirements indicated are the minimum acceptable and the State retains the right to judge the equality of any variation.

F. Unless otherwise specified here or under Section 013300 SUBMITTAL PROCEDURES, submit eight (8) copies of each submittal required for approval:

1. Substitution Requests: Substitute materials or equipment may be used if qualified by written permission from the State. Submit a list of the substitutions with qualifying data for approval prior to bidding in accordance with Section 016000 PRODUCT REQUIREMENTS.
2. Shop Drawings: Submit prints of dimensioned shop drawings, indicating equipment layout, piping, hangers, equipment bases, support details, wiring diagrams for control, and locations and sizes of pipe sleeves and duct openings. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices and components. Coordinate drawings with other trades to avoid interferences. Drawings shall be minimum 24 inches by 36 inches in size, except as specified elsewhere. Provide one (1) set of reproducible transparencies and six (6) sets of bond prints. Approval of shop drawings does not relieve the Contractor from responsibility of a complete installation or proper performance. No work shall commence until shop drawings are approved by the Contracting Officer.
    a. The Contractor shall review, stamp with his approval, and submit all Shop Drawings required by the Contract Documents.
    b. At the time of submission, the Contractor shall inform the Contracting Officer in writing of any deviations in the Shop Drawings from the requirements of the Contract Documents.
    c. By approving and submitting Shop Drawings, the Contractor certifies that he has determined and verified all field measurements and obstructions, field construction criteria, materials, catalog numbers and similar data, that he has checked and coordinated each Shop Drawing with the requirements of the work and of the Contract Documents and that all equipment fits within designated spaces.
3. Certificates of Conformance or Compliance:
    a. Submit certification from the manufacturer attesting that materials and equipment to be furnished for this project comply with the requirements of this specification and of the reference publications. Preprinted certifications will not be acceptable; certifications shall be in the original. The certification shall not contain statements that could be interpreted to imply that the product does not meet all requirements specified, such as "as good as"; "achieve the same end use and result as materials formulated in accordance with the referenced publication," "equal or exceed the service and performance of the specified material." The certification shall simply state that the product conforms to the requirements specified.
    b. Standards Compliance: When materials or equipment are specified to conform to the standards of organizations such as the American National Standards Institute (ANSI), Air Conditioning and Refrigeration Institute (ARI), Air Movement and Control Association (AMCA), American Society for Testing and Materials (ASTM), Factory Mutual Engineering and Research Corporation (FMERC or FM), National Electrical Manufacturers Association (NEMA), National Fire Protection Association (NFPA), and Underwriters Laboratories (UL), proof of such conformance shall be submitted to the State for approval. If an organization uses a label or listing to indicate compliance with a particular standard, the label or listing will be acceptable evidence, unless otherwise specified in the individual sections. In lieu of the label or listing, the Contractor may submit a certificate from an independent testing organization, which is competent to perform acceptable test and is approved by the State. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and the item conforms to the specified organization's standard. For materials and equipment whose compliance with organizational standards of specifications is not regulated by an organization using its own listing or label as proof of compliance, a

certificate of compliance from the manufacturer shall be submitted for approval. The certificate shall identify the manufacturer, the product and the referenced standard and shall simply state that the manufacturer certifies that the product conforms to all requirements of the project specification and of the referenced standards listed.

4. Product Data: Submit data of equipment showing manufacturer's name, trade name, catalog model or number, project specification and paragraph reference, material specifications, performance data, certified dimensions and motor sizes. Performance data shall meet the criteria and standards specified in the technical sections for the model being furnished. Submit eight (8) complete sets. Equipment and material shall not be ordered without prior approval of the submittal from the State.
5. Reports: Submit as required by individual technical sections.
6. Operation and Maintenance Manual: Submit bound copies of the Operating and Maintenance Manual on all equipment and the system as a whole.
7. Equipment Listing: Submit schedules of mechanical equipment which include a complete list of materials and equipment together with names and addresses of manufacturers and the Hawaii based authorized representative, catalog numbers, and trade names.
8. Maintenance Service Contract: Submit Maintenance Service Contract as required in paragraph 3.08.
9. As-Built Drawings: Submit As-Built drawings as required in Section 017700 CLOSEOUT PROCEDURES.

1.5 LAWS, REGULATIONS AND CODES

A. The following shall govern where applicable; the Uniform Building Code as amended by the City and County of Honolulu Code, State of Hawaii Department of Health Regulations, the Uniform Fire Code as amended by the City and County of Honolulu Code, National Fire Protection Association Standards, the Uniform Plumbing Code as amended by the City and County of Honolulu Code, OSHA Rules and Regulations and all other codes and standards referenced in these specifications and as adopted by City and County of Honolulu. Where requirements differ in these codes and standards, the more stringent shall apply.

1.6 PERMITS AND INSPECTIONS

A. Obtain and pay for all fees, permits, licenses, assessments, connection charges and inspections required for this project.

B. The Contractor shall apply and pay for all necessary inspections required by any public authority having jurisdiction.

1.7 MANUFACTURER’S RECOMMENDATIONS

A. Equipment installed under this Division of the Specifications shall be installed according to the manufacturer's recommendations, unless otherwise shown on the drawings or specified in this section. Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the equipment being installed, printed copies of these recommendations shall be furnished to the Contracting Officer, prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause or rejection of the equipment.

B. Certain specified construction and details may not be regularly included in the manufacturer's catalogued product. The Contractor shall provide the material or equipment complete as

specified.

1.8 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Bound Instructions: Unless otherwise indicated, furnish six (6) copies and (1) CD of an operation, maintenance, and troubleshooting manual for each item of equipment and the system as a whole. Furnish the manual bound in hardback binders or an approved equivalent. Furnish one (1) complete manual prior to the time that equipment tests are performed and furnish the remaining manuals before the contract is completed. Inscribe the following identification on the cover; the words OPERATION AND MAINTENANCE MANUAL, the name and location of the building, the name of the Contractor, the name of the Consultant, date, and the contract number. The manual shall include the names, addresses and telephone numbers of each subcontractor installing equipment and of the local representative for each item of equipment. Also include a list of equipment by manufacturer, with the model number and serial number, tag number, quantity of each unit, location of unit, and area served. When standard manufacturer's brochures are used, adequately indicate (highlight, arrow, etc.) the project related information and delete (X or cross-out) the non-applicable information. Flysheet or divider sheet shall be placed before instructions covering each subject. The instruction sheets shall be approximately 8-1/2 by 11 inches, with large sheets of drawings folded in. The manual shall have a table of contents and be assembled to conform to the table of contents with the tab sheets placed before instructions covering the subject. The instructions shall be legible and easily read, with large sheets of drawings folded in. The manual shall include:
   1. System layout showing equipment, ductwork, piping, controls, etc.;
   2. Wiring and control diagrams with data to explain detailed operation and control of each item of equipment;
   3. A control sequence describing startup, operation and shutdown;
   4. Description of the function of each principal item of equipment;
   5. The procedure for starting;
   6. The procedure for operating;
   7. Shutdown instructions;
   8. Maintenance instructions;
   9. Lubrication schedule including type, grade, temperature range and frequency;
   10. Manufacturer's bulletins, cuts and descriptive data;
   11. Safety precautions, test procedures; performance data; and
   12. Parts list. The parts lists for equipment shall indicate the sources of supply, recommended spare parts and the service organization which is reasonably convenient to the project site.

   The manual shall be complete in all respects for equipment, controls, accessories and associated appurtenances provided.

1.9 SPARE-PARTS DATA

A. After approval of materials and equipment and one month prior to the date of beneficial occupancy, the Contractor shall furnish a complete list of parts and supplies, with current source of supply.

1.10 SUBSTITUTION OF EQUIPMENT OR MATERIAL

A. Design is based on equipment and material as described in drawings. Any changes in equipment, bases, piping, connections, controls, electrical equipment specified and required by the approved substitutions shall be made by Contractor at no additional cost to the State. Contractor shall ensure proper fit, clearances, compatibility with other trades (e.g. electrical, ceiling, etc.), compatibility with controls and communication with the controls system, operation and maintainability for any equipment or material that is substituted for that indicated.

1.11 DISCREPANCIES

A. The Drawings and Specifications are intended to be cooperative. Any materials, equipment or system related to this division and exhibited on the Architectural, Electrical or Mechanical Drawings but not mentioned in the Specifications are to be executed to the intent and meaning thereof, as if it were both mentioned in the Specifications and set forth on the Drawings.

B. In case of differences between the Drawings and Specifications, the Specifications shall govern first, and then the Drawings. Large scale details shall take precedence over small scale Drawings as to the shape and details of construction. Specifications shall govern as to materials.

C. Drawings and Specifications are intended to be fully cooperative and to agree, but should any discrepancy or apparent difference occur between Drawings and Specifications or should errors occur in the work of others affecting the work, the Contractor shall notify the Contracting Officer at once. If the Contractor proceeds with the work affected without instructions from the State, he is responsible for that change and shall correct any resultant damage, rework, extra work or defect at no additional cost to the State. All interpretations of Drawings and Specifications shall be clarified by the Contracting Officer.

1.12 OMISSIONS

A. It is the intent of the plans and specifications to provide a complete installation. Should there be omissions, the Contractor shall call the attention of the Contracting Officer to such omissions in fifteen (15) days advance of the date of bid opening so the necessary corrections can be made.

1.13 GUARANTEE AND CERTIFICATE

A. The Contractor shall guarantee and certify in writing the following items:
   1. All equipment, piping, accessories and material furnished for a period of one (1) year commencing after 30 consecutive days of trouble-free operation from the date of final acceptance against all defects in material and workmanship. If any equipment, piping or material fails, does not operate satisfactorily or shows undue wear, the Contractor will be notified, and shall be required to correct the defect and damage to other work caused by such defect, immediately and at no additional cost to the State. If the above period of warranty does not coincide with the manufacturer's standard warranty period, the contractor shall include all costs for extending the warranty for the period specified above in his bid.
   2. All equipment, piping and materials to provide the results specified or shown.

3. All equipment to be properly installed in strict accordance with manufacturer's recommendations and to be free of vibration or objectionable noise.
4. All piping to be drip free and properly installed to be free of vibration, pounding or objectionable noise.

B. The above guarantee shall not be interpreted as voiding, limiting or reducing any equipment manufacturer's warranty or any guarantee permitted by law.

C. The State shall have the right to require a written certificate, dated and signed by a responsible employee of the Contractor, evidencing the performance of any portion of the work, or any testing; as a condition precedent to the acceptance of any work or the result of any test. Whenever a regulatory agency performs inspections or tests of any portion of the work, a certificate shall be furnished by the Contractor showing the inspection or test was satisfactorily passed.

D. Contractor shall provide a written guarantee that all work is as specified, and shall be bound to reinstall material or equipment defective due to workmanship or materials for a period of one (1) year commencing after 30 consecutive days of trouble-free operation from the date of final acceptance by the State. Contractor shall not be responsible, however, for defects proven to the State's satisfaction to be due to misuse, accident or negligence by other parties.

E. Further, Contractor shall be held responsible for all damages to any part of the premises, building or contents caused by leaks or other defects in pipe, equipment or materials provided under this specification, of a period of one (1) year commencing after 30 consecutive days of trouble-free operation from the date of final acceptance of the installation by the Contracting Officer.

F. Terms of this guarantee are in addition to other guarantee provisions of the specifications, and do not substitute for other more stringent terms, if any.

G. In addition to the Guarantee on materials and workmanship, Installer shall provide a Maintenance Service Contract, Countersigned by the General Contractor, that will validate said guarantee.

1.14 ELECTRICAL WORK

A. All power wiring, including final hookup to all mechanical equipment will be provided under the Electrical Division of this Specification. Control devices for mechanical systems required that are energized from the power system (i.e. 100 volts and higher) shall be provided by the Mechanical Subcontractor. The power wiring, conduits and appurtenant work including connection to the mechanical equipment and control devices shall be provided by the Electrical Subcontractor.

B. Electrical work under Electrical Division of the specifications is based on the electrical rating of equipment indicated on the Mechanical Drawings. Additional electrical work caused by any deviation under the requirements of the Mechanical Division drawings and specifications shall be paid for by the Mechanical Subcontractor.

C. All control wiring for communication, signals and control power less than 100 volts are included under mechanical work and shall be in accordance with Division 26 ELECTRICAL requirements, except where specified otherwise in Division 23 HEATING, VENTILATING, AND AIR CONDITIONING.

D. The Mechanical Subcontractor shall furnish all starters, variable speed drives, control

transformers, motor controllers, any disconnect devices specified as part of the mechanical equipment and any other electrically powered devices for installation by the Electrical Subcontractor. The Mechanical Subcontractor shall turn over these items to the Division 26 ELECTRICAL Subcontractor at the site after receipt of notice from the Electrical Subcontractor that he is ready to install said items. The Electrical Subcontractor shall install these devices and provide the labor and materials to connect to the power system.

1.15 SAMPLES

A. When called for in the Technical Sections, furnish samples of materials which accurately represent if not identical to the materials to be used. Where samples are specified to demonstrate method of installation, furnish all materials, labor, ingredients and tools. Samples shall also be furnished when materials are proposed as substitutions for those specified. Materials used in the work shall be identical to samples that have been approved by the Contracting Officer.

1.16 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Furnish new equipment, materials and accessories bearing the manufacturer's identification. Coordinate deliveries to avoid interference or construction delays. Protect products during delivery, storage, installation, and the remainder of the contract period after installation.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. As specified in all sections of Division 23 HEATING, VENTILATING, AND AIR CONDITIONING.

B. Materials and equipment shall be cataloged products of manufacturers regularly engaged in production of such materials or equipment and shall be manufacturer's latest design that complies with the specification requirements. Materials and equipment shall duplicate items that have been in satisfactory commercial or industrial use at least 2 years in Hawaii prior to bid opening. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the items need not be the products of the same manufacturer except where specified. Each item of equipment shall have the manufacturer's nameplate. Name of the distributing agent in lieu of the manufacturer's nameplate will not be acceptable.

C. All materials shall be new, of equivalent or better quality than of materials specified. For ease of maintenance and parts replacement, select equipment from a single manufacturer as much as possible. Substitutions require approval.

2.2 NAMEPLATES

A. Each item of equipment shall have manufacturer's nameplate of corrosion resisting metal attached in a conspicuous location. Nameplate data shall include manufacturer's name, address, model number, serial number, capacity, rating and such other performance data as required to completely identify the item. In addition, the manufacturer shall provide a separate corrosion resisting metal tag or plastic, unless specified otherwise, to carry the equipment designation as shown on drawings. Except as otherwise specified nameplate lettering shall be stamped or engraved on the nameplate. Nameplates shall be fastened by means of corrosion resisting metal screws, rivets or wire, 14-gage. In addition, each piece of

equipment shall be provided an identification tag in accordance with the paragraph entitled "Identification Tags for Mechanical Equipment and Devices".

2.3 TOOLS AND SUPPLIES

A. Special tools and supplies shall be provided if required to maintain equipment provided for this project. The items shall be packaged or boxed to provide protection in storage, and shall be identified as to use. Tools and supplies shall be accompanied by information as to source of supply.

2.4 FACTORY-APPLIED PAINT

A. Ferrous surfaces of equipment shall have baked enamel finish painting as standard with the manufacturer. Special coating shall be applied when specified in the Technical Sections, and in such cases the coating used shall be certified in compliance with the Certificates paragraph in this section.

B. All interior, exposed ferrous support materials shall have factory-applied protective coating.

C. All exterior, exposed ferrous support materials shall have factory-applied protective prime coat as follows:
1. Pre-Treatment: Commercial Blast Cleaning in accordance with Steel Structures Painting Council No. 6 (not less than 2 mils profile).
2. Primer: Epoxy based or as recommended by the paint manufacturer and shall be asbestos-free, lead-free, cadmium-free, zinc-chromate-free and mercury-free.

2 5 MOTORS

A. Provide premium efficiency type motors designed for the supply voltages made available for this portion of the work, and with the following attributes:
1. Sized to develop the required brake horsepower and to operate satisfactorily with a voltage variation of plus or minus 10 percent;
2. Conforming to NEMA motor standards;
3. Dynamically balanced, and held to commercial tolerance;
4. Selected so that, when ambient temperature reaches 120 degrees F for a period of two hours or more, the motor will operate satisfactorily without failure.
5. With squirrel-cage type drip-proof enclosure, unless otherwise indicated, constant speed, across-the-line normal starting torque designed for quiet operation;
6. Each motor of ample size to operate its unit at proper full load and speed continuously, without heating in any part more than 40 degrees C above the temperature of the surrounding atmosphere.
7. Where TEFC motors are indicated or specified, the cast iron frame type shall be provided.

B. Where motor is used with V-belt drive, equip with a sliding base and belt guard, and motor sheave.

PART 3 EXECUTION

3.1 VERIFICATION OF DIMENSIONS

A. The Contractor shall check all dimensions at the site and shall establish all lines and levels. The Contractor shall be responsible for correctness of all dimensions and fitting of equipment, ductwork, fixtures and piping into the available space. Should field measurements show conditions that require relocation of any work, such conditions shall be reported to the Contracting Officer in advance of installation, and the work shall proceed in accordance with his decisions.

3.2 PROTECTION OF WORK IN PROGRESS

A. Ducts, conduits (if provided by Division 23 HEATING, VENTILATING, AND AIR CONDITIONING technical specifications) and pipe openings shall be closed with caps or plugs until connections are made. Equipment shall be securely covered for protection against physical or chemical damage. In areas exposed to weather, materials unused at the end of each day's work shall be stored in weather-protected locations. Damage to materials or equipment due to the Contractor's neglect shall be repaired or replaced to the satisfaction of the Contracting Officer by, and at the expense of the Contractor

3.3 LOCAL TECHNICAL SUPPORT

A. The mechanical equipment suppliers that furnish equipment for this project shall have a local Hawaii sales and service office, staffed with factory trained representatives fully capable of providing instruction, routine maintenance and emergency maintenance service on all system components supplied for this project. If the maintenance service is provided by a separate company, that company shall be specifically trained by manufacturer and authorized to perform maintenance on the equipment furnished for this project.

3.4 SAFETY REQUIREMENTS

A. Belts, pulley, chains, gears, couplings, projecting setscrews, keys and other rotating parts located so that any person can come in close proximity thereto shall be fully enclosed or properly guarded. High temperature equipment and piping so located as to endanger personnel or create a fire hazard shall be properly guarded or covered with insulation of a type as specified in other mechanical sections. Items such as catwalks, ladders and guard rails shall be provided where required for safe operation and maintenance of equipment.

3.5 PAINTING

A. Unless specified in other mechanical specification sections, the Contractor shall be responsible for complete coverage in painting all exposed ferrous metal that has not been factory finish coated.

3.6 PIPING IDENTIFICATION

A. Identification of all new pipe lines shall be by means of colored, waterproof, all temperature, self-adhering labels and directional arrow. Refer to painting section for color coding of existing and new piping.

B. At Contractor's option, each and every system may be identified by painting with contrasting colors, using 3/4" high minimum stencil letters. Painting shall be done by the Mechanical Contractor.

C. All exposed pipes, whether insulated or not shall be identified. Labels may be omitted from piping where the use is obvious, due to its connection to equipment and where the appearance would be objectionable in finished rooms, as approved by direction.

D. Identification labels shall be placed as follows:
   1. Near each valve and branch connection.
   2. Wherever piping merges or disappears from view from the floor of the room in which it is installed.
   3. Labels shall not be more than 50 feet apart.

3.7 VALVE INDEX

A. Valves shall be identified with brass tags where identification is required by other mechanical sections of these specifications.
B. Attach tags with stainless steel chains or wires to valve body or stems. Attachment shall be permanent.

C. Tag numbers shall match identification numbers shown on as-built drawings.

D. Provide 1-1/2-inch diameter brass tags for all valves with identification numbers as indicated. Each tag shall have stamped service designation and valve number designation in 1/4-inch black-filled letters over 1/2-inch black-filled numbers. Tags shall be fastened to valves with brass jack chain. Chart of all valves shall be furnished by the Contractor and shall include:
   1. Valve I.D. number
   2. Location
   3. Purpose of system
   4. Normally open or normally closed

3.8 IDENTIFICATION TAGS FOR MECHANICAL EQUIPMENT AND DEVICES

A. All mechanical equipment, panels, control devices such as temperature sensors, carbon dioxide sensors, pressure transmitters, pressure gauges and other devices shall be provided with an identification tag that indicates the name of the item. The name shall coincide with the Operations and Maintenance Manual and the as-built drawings.

B. The tag shall be plastic nameplate, 1" x 3" minimum size, engraved laminated phenolic, white with black core. The tags shall be fastened to the equipment or device with metal screws or fastened with a brass jack chain if it cannot be mounted with screws.

3.9 FIELD INSTRUCTION

A. Upon completion of the work and at a time designated, the services of one or more qualified personnel shall be provided by the Contractor for a period of not less than 40 hours to train and provide technical assistance to the State’s representatives in the operation and maintenance of the air conditioning and ventilation system. These field instructions shall cover all the items contained in the bound instructions. Submit course outline, instructor’s name and an on-site training schedule. The training shall be as follows:
   1. Provide overview and provide as-built plans, diagrams, operating and technical manuals for the entire air conditioning and ventilation system.

2. Identify, locate and explain the function of control devices at individual pieces of air conditioning units.
3. Identify, locate and explain the operation and access of the control panels for each piece of equipment. Explain the sequence of operation and the control setpoints and how to change setpoints.

3.10 ONE YEAR MAINTENANCE SERVICE CONTRACT

A. In addition to the guarantee on materials and workmanship, the installer shall submit copies of the Maintenance Service Contract, countersigned by the Contractor, that will validate the guarantee.

B. The maintenance service shall extend for a period of one (1) year commencing after 30 consecutive days of trouble-free operation after the Project Acceptance Date or the equipment acceptance date, if earlier than the Project Acceptance Date, and shall include all labor, materials, equipment and parts necessary to service the complete system, in accordance with the attached Schedule of Maintenance Service so as to assure proper operation and function of the system. All costs for the periodic maintenance, including emergency calls, shall be borne by the Contractor. The maintenance period and guarantee period shall run concurrently (same start and stop dates). Should the contractor default in maintenance servicing, the service contract shall restart and continue until completion and the warranty shall be extended to match the new service period.

C. Trouble-free operation is defined as a non-disabling condition of a non-recurring failure or disruption and the following:
1. The system shall be free of all discrepancies, contamination and debris which requires correction in excess of those described for the monthly service which is included in the Schedule of Maintenance.
2. The system is maintaining operational conditions and other parameters as measured during acceptance tests.

D. Periodic basis shall mean a minimum of once every month unless specifically noted otherwise. Where the Manufacturer's Service Manual requires a shorter period, the shorter period shall apply. Where there are more than one service periods shown, all services shall be provided. For example, if a monthly and annual service are indicated, the annual service shall be performed in addition to the monthly service scheduled for that month.

E. For each system provided by this contract, the Installer shall include a listing of the following items along with the Maintenance Service Contract:
1. Name of the servicing contractor.
2. System acceptance date.
3. Service contract expiration date.
4. Monthly inspection schedule for the maintenance period.
5. Itemized listing of the equipment covered under the service contract, including a description of the equipment identified, its model and serial numbers and manufacturer's name(s).

F. The Maintenance Service Contract shall be submitted along with the Operations and Maintenance Manual on/or before the Project Acceptance Date.

Distribution of submittal:

1copy: Contractor

1 copy: DAGS Windward District
1 copy: DAGS Quality Control Branch
2 copies: DAGS Central Services Division
2 copies: User (District Office and School)

G. The Contractor shall keep a separate log recording all maintenance calls to the project at Contractor's office. Log shall include at least the following information.
1. Name of person making service call.
2. Date of call.
3. Time in and out from project.
4. Nature of call.
5. Equipment readings and maintenance performed.
6. The type and cost (labor, materials, parts and equipment) of repair work performed on the unit, if any.
7. Documents and other data pertaining to the maintenance performed.

It will be the responsibility of the Contractor to maintain the report/checklist by recording the above noted date after each scheduled maintenance and emergency repairs, and have the checklist available for inspection at the building site. The report shall be sufficiently detailed to properly reflect the past maintenance history of the equipment.

Reports shall be prepared on contractor - furnished standardized forms and signed by the Building's maintenance representative. A copy of the report shall be submitted to the Building's maintenance representative within 2 working days after each visit. This submittal is in addition to the normal submittal requirements of the contract.

In addition, the Contractor shall submit written reports of maintenance performed within seven (7) days to the Contracting Officer. (See Service Maintenance Report form attached)

H. Work Schedule: All maintenance work shall be performed between the hours of 7:30 a.m. to 4:00 p.m., on normal working days, Monday through Friday, excluding State holidays.

The contractor shall notify the Building's maintenance representative at least 4 working days prior to the service work date.

I. Trouble Calls:
1. Emergency service and repairs required between regular service calls shall be rendered within 24 hours after the Contractor is notified, non-work days excluded.
2. The Contractor shall call the Contracting Officer and DAGS Central Services Division (Phone No. 831-7935) the next working day after being notified of the problem and report the status of repairs.

J. All costs for periodic maintenance services and for emergency calls shall be included in the lump sum bid price.

K. Maintenance Schedule: As described on attachments following this section:
Attachment A - Schedule of Maintenance Service - Air Conditioning and Ventilation System and Attachment B –Direct Digital Controls.

L. The Maintenance Service Contract does not include repairs resulting from vandalism, negligent use or misuse of equipment.

3.11 CLEANUP AND WORK PRACTICES

A. The Contractor shall keep the job site free of debris, litter, discarded parts, etc. and shall clean all oil drippings during the daily progress of work. The Contractor shall remove all tools, parts and equipment from the service areas upon completion of the work.

B. The Contractor shall exercise caution during the progress of his maintenance and repair work to prevent damage to the ceilings, roofing and other building structure. The Contractor shall restore all damages, caused by his negligence, to its original condition at his own expense.

SERVICE MAINTENANCE REPORT

DATE:_____SHEET NO._____

1. Name of Facility and Location: _____

2. Submitted By: _____

3. Date of Service Call: _____

4. Name of Person(s) Making Call: _____

5. Time In, Time Out at Site: _____

6. Person(s) Contacted: _____

7. Nature of Service Call: (Routine Maintenance or Emergency, Explain)

_____

_____

8. Equipment Readings and Maintenance Performed: (List all items serviced: identify - 8a, 8b, 8c, . . . ,etc.):

_____

_____

_____

_____

ATTACHMENT A
SCHEDULE OF MAINTENANCE SERVICE

AIR CONDITIONING AND VENTILATION SYSTEM

All services performed by the Contractor shall include applicable items listed but shall not be limited to the following maintenance tasks:

A. PACKAGED WATER CHILLERS

Monthly Service

1. Check and record entering and leaving water temperatures and pressures of chiller and water-cooled condenser in "maintenance log book."
2. Check and record compressor refrigerant suction and discharge pressure.
3. Visual check for water, refrigerant and oil leakage; correct or repair as required.
4. Visual check vibration isolator mounts.
5. Adjust chilled water temperature setting for seasonal change.
6. Check refrigerant sight glass; change filter/drier if moisture indicated.
7. Note and run system operation through complete operating cycle and adjust for proper operation. Certify performance of monthly maintenance service and correct and report all discrepancies.

Quarterly Service

1. Check each chiller's response at various cooling load conditions for proper operation and calibration of capacity control system.
2. Check operation of oil failure switch; record settings.
3. Test and adjust "make-up" water and expansion tank.
4. Certify performance of quarterly maintenance service and correct and report all discrepancies.

Semi-Annual Service

1. Remove heads of condenser and internally brush tubes at the same time cooling tower is cleaned.
2. Certify performance of semi-annual maintenance service and correct and report all discrepancies.

Annual Service

1. Change compressor oil; clean or replace strainer and oil filter.
2. Megger (electrical test to measure wire insulation resistance, i.e. condition) chiller/compressor motor; check starter relay and control contacts and electrical connections for tightness and clean as required.
3. Test operate control switches, compressor unloading and safeties; calibrate and record settings. Adjust as required.
4. Submit and certify performance of annual maintenance service and correct and report in writing to Manager-in-Charge all discrepancies.

B. COOLING TOWER

Quarterly Service

1. Check and adjust water make-up float valve and bleed rate.
2. Check general condition of tower interior and water distribution pattern.
3. Check and lubricate motor and fan bearings.
4. Check all drives for wear; check oil level and refill as required.
5. Remove foreign material from inside the tower.
6. Check for leaks, patch, correct or repair as required.
7. Certify performance of monthly maintenance service, correct and report all discrepancies.

Semi-Annual Service

1. Drain, clean and flush tower; coordinate with water treatment service.
2. Clean condenser suction screen, drift eliminators and spray nozzles.
3. Certify semi-annual cleaning of towers and correct and report all discrepancies.

C. PUMPS

Quarterly Service

1. Lubricate and check pump and motor bearings for abnormal temperature and unusual noise or vibration and repair as needed.
2. Check mechanical seal for leakage. If leaking, Adjust, tighten or replace as required.
3. Check variable speed drive for proper operation. Adjust, reset and calibrate as required to maintain the sequence of operation.
4. Certify performance of quarterly maintenance service and correct and report all discrepancies.

Semi-Annual Service

1. Remove and clean strainer for all condenser pumps after tower cleaning.
2. Check, blow down, and clean strainer to all pumps. Remove and clean strainer if excessive debris is noted.
3. Check condition of insulation; re-insulate as necessary.
4. Log suction and discharge pressures.
5. Clean and remove all dust and foreign matter. Clean all rust spots and scratches and tough-up paint with matching color.
6. Lubricate pump motor bearings as required.
7. Check motor coupling for alignment; check and make sure mounting bolts are secure.
8. Certify performance of semi-annual maintenance service and correct and report all discrepancies.

D. HEAT PUMP WATER HEATER

Monthly Service

1. Check and record entering and leaving water temperatures and pressures of evaporator and water-cooled condenser in "maintenance log book."
2. Check and record compressor refrigerant suction and discharge pressure.
3. Visual check for water, refrigerant and oil leakage; correct or repair as required.

4. Visual check vibration isolator mounts.
5. Adjust hot water temperature setting for seasonal change.
6. Check refrigerant sight glass; change filter/drier if moisture indicated.
7. Note and run system operation through complete operating cycle and adjust for proper operation. Certify performance of monthly maintenance service and correct and report all discrepancies.

Quarterly Service

1. Check heat pump response at various load conditions for proper operation and calibration of capacity control system.
2. Check operation of oil failure switch; record settings.
3. Certify performance of quarterly maintenance service and correct and report all discrepancies.

Annual Service

1. Remove heads of condenser and internally brush tubes.
2. Change compressor oil; clean or replace strainer and oil filter.
3. Megger (electrical test to measure wire insulation resistance, i.e. condition) compressor motor; check starter relay and control contacts and electrical connections for tightness and clean as required.
4. Test operate control switches, compressor unloading and safeties; calibrate and record settings. Adjust as required.
5. Submit and certify performance of annual maintenance service and correct and report in writing to Manager-in-Charge all discrepancies.

E. VALVES, CHILLED WATER AND CONDENSER WATER LINES, EQUIPMENT AND SUPPORTS

1. The Contractor shall exercise all equipment shut-off valves annually for proper operation and tightness.
2. Wirebrush, prime and paint rust from exterior pipe, equipment and support surface to prevent further rusting.
3. Certify that all discrepancies are reported and corrected.

F. TEMPERATURE CONTROLS (FOR PACKAGED EQUIPMENT WITH INTERNAL CONTROLS)

Quarterly Service

1. Check control devices for proper operation, sticking stems and calibration; repair or replace weak or broken springs and all other parts.
2. Check automatic dampers for tightness in closing, bent blades and defective linkage; lubricate connections for free movement and repair as required.
3. Adjust thermostat to maintain 75 degrees F room temperature or operation set points as desired.
4. Certify performance of quarterly maintenance service and that all discrepancies are reported and corrected.

G. WATER TREATMENT SYSTEM

See Section 15189 – WATER TREATMENT FOR AIR CONDITIONING for requirements.

ATTACHMENT B
SCHEDULE OF MAINTENANCE SERVICE

DIRECT DIGITAL CONTROLS

All services performed by the Contractor shall include applicable items listed but shall not be limited to the following maintenance tasks:

Quarterly Service

1. Check circuits and operation of all temperature controls and sequencing system for air conditioning system, including dampers and valves in accordance with the sequence of operation.
2. Check control devices for proper operation, sticking stems and calibration; repair or replace weak or broken springs and all other parts.
3. Check automatic dampers for tightness in closing, bent blades and defective linkage; lubricate connections for free movement and repair as required.
4. Adjust temperature setpoint to maintain 75 degrees F room temperature or operation set points as desired.
5. Check setpoints of all adjustable setpoint parameters.
6. Printout points list with the recorded readings for each point taken at the time of the service visit. Compare readings to previous quarter's data and report any abnormal or unexpected changes.
7. Certify performance of annual maintenance service and correct and report all discrepancies.

Annual Service

1. Check calibration of all field devices and recalibrate where required.
2. Update any software that has been revised with a more current version if a new release has been made since the initial construction. Check system is meeting sequence of operation. Reprogram as required to meet specified sequence of operation.
3. Provide all services of quarterly service.
4. Certify performance of annual maintenance service and correct and report all discrepancies.

END OF SECTION

SECTION 230593 – TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Scope of Work: Central Plant Modifications

B. The work includes testing, adjusting, and balancing (TAB) of new air conditioning system, including equipment and ducts, which are located within the building.

1.2 RELATED WORK SPECIFIED IN OTHER SECTIONS

A. Mechanical work as specified in Section 230300 GENERAL MECHANICAL REQUIREMENTS unless specified otherwise in other sections of Division 23 HEATING, VENTILATING, AND AIR CONDITIONING.

B. Air conditioning and ventilation system controls specified in Section 230923 DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

D. Central refrigeration equipment specified in Section 236410 CENTRAL REFRIGERATION EQUIPMENT.

1.3 SUBMITTALS

A. Submit in accordance with SECTION 013300 SUBMITTAL PROCEDURES and Section 230300 GENERAL MECHANICAL REQUIREMENTS.

B. Certificates:
1. Independent TAB agency personnel qualifications
2. Design review report
3. Pre-field TAB engineering report
4. Advanced notice TAB field work
5. Check out list

C. Independent TAB Agency Personnel Qualifications: For agency proposed for approval, submit information certifying that: The TAB agency is a first tier subcontractor who is not affiliated with any other company participating in work on this contract; the work to be perform by the TAB agency shall be limited to testing, adjusting, and balancing of HVAC air and water systems to satisfy the requirements of this specification section. Submit the following, for the agency, to the Engineer for approval in compliance with paragraph entitled "TAB Personnel Qualification Requirements."
1. Independent AABC or NEBB certified TAB agency:
    a. TAB agency: AABC registration number and expiration date of current certification; or NEBB certification number and expiration date of current certification.
    b. TAB team supervisor: Name and copy of AABC or NEBB TAB supervisor certificate and expiration date of current certification.
    c. TAB team field leader: Name and documented evidence that the team field leader meets the qualification requirements.
    d. TAB team field technicians: Names and documented evidence that each field technician meets the qualification requirements.
    e. Current certificates: Registrations and certifications shall be current, and valid for

the duration of this contract. Certifications which expire prior to completion of the TAB work, shall be renewed in a timely manner so that there is no lapse in registration or certification. TAB agency or TAB team personnel without a current registration or current certification shall not perform TAB work on this contract.

f. Replacement of TAB team members: Replacement of members may occur if each new member complies with the applicable personnel qualifications and each is approved by the Engineer.

D. Design Review Report: Submit typed report describing omissions and deficiencies in the HVAC system's design that would preclude the TAB team from accomplishing the duct leakage testing work and the TAB work requirements of this section. Provide a complete explanation including supporting documentation detailing the design deficiency. State that no deficiencies are evident if that is the case.

E. Pre-Field TAB Engineering Report: Submit report containing the following information:

1. Step-by-step TAB procedure:
   a. Strategy: Describe the method of approach to the TAB field work from start to finish. Include in this description a complete methodology for accomplishing the TAB field work session.
   b. Procedural steps: Delineate fully the intended procedural steps to be taken by the TAB field team to accomplish the required TAB work of each air distribution system and each water distribution system. Include intended procedural steps for TAB work for subsystems and system components.
2. Pre-field data: Submit AABC or NEBB or SMACNA HVACTAB data report forms with the following pre-field information filled in:
   a. Design data obtained from system drawings, specifications, and approved submittals.
   b. Notations detailing additional data to be obtained from the contract site by the TAB field team.
   c. Designate the actual data to be measured in the TAB field work.
   d. Provide a list of the types of instruments, and the measuring range of each, which are anticipated to be used for measuring in the TAB field work. By means of a keying scheme, specify on each TAB data report form submitted, which instruments will be used for measuring each item of TAB data. If the selection of which instrument to use, is to be made in the field, specify from which instruments the choice will be made. The instrument key number shall be placed in the blank space where the measured data would be entered.
3. Prerequisite HVAC work checkout list: A list of inspections and work items which are to be completed by the Contractor, and submitted and approved by the Engineer prior to the TAB team coming to the contract site. At a minimum, a list of the applicable inspections and work items listed in the NEBB TABES, Section III, "Preliminary TAB Procedures" under paragraphs entitled "Air Distribution System Inspection" and "Hydronic Distribution System Inspection." Also, list as prerequisite work items, the deficiencies pointed out by the TAB subcontractor in his design review report.

F. Advanced Notices: Submit "Advanced Notice for TAB Field Work" in writing.

G. Completed Check Out Lists: Submit "Prerequisite HVAC Work Checkout List" and certify in writing that each item has been checked and is operating as designed.

H. Field Test Reports:
1. Certified TAB report
2. Field Test Reports: Submit certified reports in the specified format including the above data.
a. Certified TAB Reports:
(1) Report format: Bind the report with a waterproof front and back cover. Include a table of contents identifying by page number the location of each report. Report forms and report data shall be typewritten. Handwritten report forms or report data are not acceptable.
(2) Temperatures: On each TAB report form reporting TAB work accomplished on HVAC thermal energy transfer equipment, include the indoor and outdoor dry bulb temperature range and indoor and outdoor wet bulb temperature range within which the TAB data was recorded.
(3) Instruments: List the types of instruments actually used to measure the tab data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date.
(4) Certification: Include the typed name of the TAB supervisor and the dated signature of the TAB supervisor.
3. TAB Submittal and Work Schedule: Compliance with the following schedule is the Contractor's responsibility.
a. TAB Field Work: At a minimum of 30 calendar days prior to start of field check, accomplish TAB field work; submit certified TAB report; and conduct field check.

1.4 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.
1. ASSOCIATED AIR BALANCE COUNCIL (AABC)
AABC MN-1 Testing and Balancing Heating, Ventilating and Air Conditioning Systems
2. AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
ANSI S1.4 (ASA 47) Sound Level Meters
ANSI S1.11 (ASA 65) Octave- Band and Fractional-Octave-Band Analog and Digital Filters
3. AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR-CONDITIONING ENGINEERS, INC. (ASHRAE)
ASHRAE HA Handbook, HVAC Applications
4. NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)
NEBB TABES Testing, Adjusting, Balancing of Environmental Systems
5. SHEET METAL & AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION, INC. (SMACNA)
SMACNA HVACTAB HVAC Systems Testing, Adjusting and Balancing

1.5 QUALITY ASSURANCE

A. Modifications of References: Accomplish work in accordance with referenced publications of AABC or NEBB except as modified by this section. In the references referred to herein, consider the advisory or recommended provisions to be mandatory, as though the word "shall" had been substituted for the words "should" or "could" or "may" wherever they appear.

B. TAB Personnel Qualification Requirements:
1. Independent AABC or NEBB Certified TAB Agency:

a. Provide services of a TAB agency certified by AABC or NEBB to perform and manage TAB work on HVAC air systems. This TAB agency shall not be affiliated with any company participating in any other phase of this contract, including design, furnishing equipment, or construction.

2. TAB Team Personnel: The TAB team approved to accomplish work on this contract shall be full-time employees of the TAB agency. No other personnel shall do TAB work on this contract.
   a. TAB Team Supervisor: Supervisor shall be qualified by AABC or NEBB as a TAB supervisor or a TAB engineer.
   b. TAB Team Field Leader: Leader shall have satisfactorily performed full-time supervision of TAB work in the field for not less than 3 years immediately preceding this contract's bid opening date.
   c. TAB Team Field Technician: Technician shall have satisfactorily assisted a TAB team field leader in performance of TAB work in the field for not less than one year immediately preceding this contract's bid opening date.

C. Responsibilities: The Contractor shall be responsible for ensuring compliance with the requirements of this section. The following delineation of specific work responsibilities is specified to facilitate execution of the various work efforts by personnel from separate organizations. This breakdown of specific duties is specified to facilitate adherence to the schedule.
   1. Contractor:
      a. TAB personnel: Ensure that the TAB work is accomplished by a group meeting the requirements specified in paragraph entitled "TAB Personnel Qualification Requirements".
      b. Pre-TAB meeting: Attend the meeting with the TAB Supervisor, and ensure that a representative is present for the sheetmetal contractor, mechanical contractor, and electrical contractor.
      c. HVAC documentation: Furnish one complete set of the following HVAC-related documentation to the TAB Agency:
         (1) Contract drawings and specifications
         (2) Approved submittal data for equipment
         (3) Construction work schedule
         (4) Up-to-date revisions and change orders for the previously listed items
         Submittal and work schedules: Ensure that the schedule for submittals and work required by this section are met.
      d. Coordination of supporting personnel: Provide the technical personnel, such as factory representatives or HVAC controls installer required by the TAB field team to support the TAB field measurement work. Provide equipment mechanics to operate HVAC equipment to enable TAB field team to accomplish the TAB field measurement work. Ensure these support personnel are present at the times required by the TAB team, and cause no delay in the TAB field work. Conversely, ensure that the HVAC controls installer has required support from the TAB team field leader to complete the controls check out.
      e. Deficiencies: Ensure that equipment defects, installation deficiencies, and design deficiencies reported by the TAB team field leader are brought to the attention of the Contracting Officer. Ensure that design deficiencies reported by the TAB field leader, or the TAB team supervisor, are transmitted to the Contracting Officer within 4 calendar days from date of receipt from the TAB agency.
      f. Prerequisite HVAC work: Complete check out and debugging of HVAC equipment, ducts, and controls prior to the TAB engineer arriving at the project site to begin the TAB work. Debugging includes searching for and eliminating malfunctioning elements in the HVAC system installations, and verifying all

adjustable devices are functioning as designed. Prior to the TAB field team's arrival, ensure completion of the applicable inspections and work items listed in the TAB team supervisor's pre-field engineering report. List as prerequisite work items, the deficiencies, pointed out by the TAB team supervisor in the design review report. Ensure that the TAB Agency gets a copy of the prerequisite HVAC work checklist specified in the paragraph entitled "Submittals." Do not allow the TAB team to commence TAB field work until all of the following are completed.

(1) HVAC system installations are fully complete.

(2) HVAC prerequisite checkout work lists have been completed, submitted, and approved.

(3) HVAC system filters are clean for TAB field work.

g. Advance notice: Furnish to the Engineer with advance written notice for each event, the commencement of the field work and for the commencement of the TAB field work.

2. TAB Agency: Provide the services of a TAB team which complies with the requirements of paragraph entitled "TAB Personnel Qualification Requirements."

a. TAB Team Supervisor:

(1) Overall management: Supervise and manage the overall TAB team work effort, including preliminary and technical TAB procedures and TAB team field work.

(2) Pre-TAB meeting: Attend meeting with Contractor.

(3) Design review report: Review project specifications and accompanying drawings to verify that the air systems and water systems are designed in such a way that the TAB Team Field Leader can accomplish the work in compliance with the requirements of this section. Verify the presence and location of permanently installed test ports and other devices needed, including gauge cocks, thermometer wells, flow control devices, circuit setters, balancing valves, and manual volume dampers.

(4) Support required: Specify the technical support personnel required from the Contractor other than the TAB agency; such as factory representatives for temperature controls or for complex equipment. Inform the Contractor in writing of the support personnel needed and when they are needed. Furnish the notice as soon as the need is anticipated, either with the design review report, or the pre-field engineering report or during the TAB field work.

(5) Pre-field engineering report: Utilizing the following HVAC-related documentation; contract drawings and specifications, approved submittal data for equipment, up-to-date revisions and change orders; prepare this report.

(6) Prerequisite HVAC work checklist: Ensure the Contractor gets a copy of this checklist at the same time as the pre-field engineering report is submitted.

(7) Technical Assistance for TAB Work: Provide immediate technical assistance to the TAB field team for the TAB work.

(8) Certified TAB report: Certify the TAB report. This certification includes the following work:

(a) Review: Review the TAB field data report. From this field report, prepare the certified TAB report.

(b) Verification: Verify adherence, by the TAB field team, to the TAB plan prescribed by the pre-field engineering report and verify adherence to the procedures specified in this section.

(9) Design deficiencies: Submit in writing as soon as possible, to the Contractor and the Engineer, each design deficiency reported by the TAB field team. Provide, in this submittal, a complete explanation including supporting

documentation detailing the deficiency.

(10) TAB Field Check: The TAB team supervisor shall attend and supervise TAB field check.

b. TAB Team Field Leader

(1) Field manager: Manage, in the field, the accomplishment of the work specified in Part 3, "Execution."

(2) Full time: Be present at the contract site when TAB field work is being performed by the TAB team; ensure day-to-day TAB team work accomplishments are in compliance with this section.

(3) Prerequisite HVAC work: Do not bring the TAB team to the contract site until a copy of the prerequisite HVAC Checklist, with all work items certified by the Contractor to be working as designed, reaches the office of the TAB Agency.

D. Re-Tab Meeting: Meet with the State's TAB representative and the designing engineer of the HVAC systems to develop a mutual understanding relative to the details of the TAB work requirements. Ensure that the TAB supervisor is present at this meeting. Requirements to be discussed include required submittals, work schedule, and field quality control.

PART 2 PRODUCTS Not Used

PART 3 EXECUTION

3.1 TAB PROCEDURES

A. TAB Field Work: Test, adjust, and balance the listed HVAC systems to the state of operation indicated on and specified in the contract design documents. Air and water systems shall be proportionately balanced and reported in the TAB report. Provide instruments and consumables required to accomplish the TAB work. Conduct TAB work on the listed HVAC systems in conformance with the AABC MN-1, or NEBB TABES, except as modified by this section:

1. Maintenance and calibration of instruments.
2. Accuracy of measurements.
3. Preliminary procedures: Test ports required for testing by the TAB engineer shall be located in the field by the TAB engineer during TAB field work. It shall be the responsibility of the sheetmetal contractor to provide and install test ports as required by the TAB engineer.
4. Air distribution systems TAB work: Air handling units, fan coil units and fans including coils, ducts, plenums, mixing boxes, and air distribution devices for supply air, return air, and outside air.
5. Water distribution systems TAB work: Chilled water, condenser water, reheat water, heat recovery water systems including chillers, condensers, cooling towers, pumps, coils, system balance valves and flow measuring devices.

B. TAB work on performance tests:
   1. Performance tests: In addition to the TAB proportionate balancing work on the air distribution systems, accomplish TAB work on the HVAC systems which directly transfer thermal energy. TAB the operational performance of the cooling systems.
   2. Ambient temperatures: On each tab report form used for recording data, record the outdoor and indoor ambient dry bulb temperature range and the outdoor and indoor ambient wet bulb temperature range within which the report form's data was recorded. That is, record these temperatures at beginning and at the end of data taking.

3.2 WORKMANSHIP

A. Conduct TAB work on specified HVAC systems until measured parameters are within plus or minus 10 percent of the design values, that is, the values specified or indicated on the contract documents. To minimize the possibility of noise at the air device, “coarse” balancing shall be performed at the duct branch and “fine” balancing shall be performed at the face of the air device.

3.3 DEFICIENCIES

A. Strive to meet the intent of this section to maximize the performance of the equipment as designed and installed. However, if deficiencies in equipment design or installation prevent TAB work from being accomplished within the range of design values specified in the paragraph entitled "Workmanship," provide written notice as soon as possible to the Contractor and the Contracting Officer describing the deficiency and recommended correction. Responsibility for correction of installation deficiencies is the Contractor's. If a deficiency is in equipment design, call the TAB team supervisor for technical assistance. Responsibility for reporting design deficiencies to Contractor is the TAB team supervisor's.

3.4 DATA FROM TAB FIELD WORK

A. After completion of the TAB work, prepare a pre-final TAB report. Data required shall be furnished by the TAB team. Except as approved otherwise in writing by the Contracting Officer, the TAB work and the TAB report shall be considered incomplete until the TAB work is accomplished to within the accuracy range specified in the paragraph entitled "Workmanship" of this section. Prepare the report neatly and legibly; the pre-final TAB report shall be the final TAB report minus the TAB supervisor's review and certification. Obtain, at the contract site, the TAB supervisor's review and certification of the TAB report. Verbally notify the Engineer’s TAB representative that the field check of the certified TAB report data can commence; give this verbal notice 48 hours in advance of when the field checking shall commence. Do not schedule field check of the certified TAB report until the specified workmanship requirements have been met or written approval of the deviations from the requirements have been received from the Engineer.

3.5 QUALITY ASSURANCE FOR TAB FIELD WORK

A. Field check: Test shall be made to demonstrate that capacities and general performance of air and water systems comply with the contract requirements.
   1. Recheck: During field check, the Contractor shall recheck, in the presence of the Engineer, random selections of data (water, air quantities, air motion, sound level readings) recorded in the certified report.
   2. Areas of recheck: Points and areas of recheck shall be selected by the engineer.

3. Procedures: Measurement and test procedures shall be the same as approved for work for forming basis of the certified report.
4. Recheck selections: Selections for recheck will not exceed 25 percent of the total number of reported data entries tabulated in the report.
5. Retests: If random tests reveals a measured quantity which is out-of-tolerance, the report is subject to disapproval at the Engineers discretion. In the event the report is disapproved, all systems shall be readjusted and tested, new data recorded, new certified reports submitted, and a new field check conducted at no additional cost to the Government.

B. Approval prerequisite: Compliance with the field checking requirements of this section is a prerequisite to the final approval of the certified TAB report submitted.

3.6 MARKING OF SETTINGS

A. Permanently mark the settings of HVAC adjustment devices including valves, splitters, and dampers so that adjustment can be restored if disturbed at any time. The permanent markings shall indicate the settings on the adjustment devices which result in the data reported on the submitted certified TAB report.

3.7 MARKING OF TEST PORTS

A. The TAB team shall permanently and legibly mark and identify the location points of the duct test ports. If the ducts have exterior insulation, these markings shall be made on the exterior side of the duct insulation. The location of test ports shall be shown on the as-built mechanical drawings with dimensions given where the test port is covered by exterior insulation.

END OF SECTION

SECTION 230700 - HVAC INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. Scope of Work: Central Plant Modifications

B. This section covers the furnishing, fabrication, delivery and installation of the insulation for air conditioning, ventilation, plumbing and generator auxiliary systems complete, including but not limited to the following:
   1. Pipe Insulation.
   2. Equipment Insulation
   3. Manufacturer's literature, shop drawings and record drawings.
   4. Inspection, test and guarantee.

1.2 RELATED WORK SPECIFIED IN OTHER SECTIONS

A. Mechanical work as specified in Section 230300 GENERAL MECHANICAL REQUIREMENTS unless specified otherwise in other sections of Division 23 HEATING, VENTILATING, AND AIR CONDITIONING.

B. Chilled water piping specified in SECTION 232113 CHILLED WATER PIPING.

1.3 SUBMITTALS

A. Submit the following in accordance with Section 230300 GENERAL MECHANICAL REQUIREMENTS.

B. Certificates of Conformance or Compliance:
   1. Submit certificates of conformance for performance and characteristics specified, the listed standards and in accordance with Section 230300 GENERAL MECHANICAL REQUIREMENTS for the following:
      a. Pipe Insulation

C. Product Data: Submit product data for the following:
   1. Pipe insulation.
   2. Equipment insulation that is not factory installed.
   3. Insulation accessories including vapor barrier, tape, and other items.

D. Listing: List of materials showing name and addresses of manufacturers; manufacturer’s local supplier’s name, address and phone number; catalog numbers and trade names.

E. Guarantee and Certificate: Submit one year guarantee and certificate in accordance with Section 230300 GENERAL MECHANICAL REQUIREMENTS.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. General:
   1. Provide materials complying with NFPA Bulletin 90-A, as determined by UL method NFPA 225-ASTM E84 or UL 181, with flame spread rating 25 and under and smoke

developed rating 50 and under.

2. Where vapor barriers are used, provide intact and continuous throughout.

2.2 PIPE INSULATION

A. All above grade indoor chilled water piping shall be insulated with Schuller Micro-Lok 650 with Vapor Barrier Jacket, Fiberglas heavy density pipe insulation with self-sealing, All Service Jacket (ASJ); Schuller; Certainteed or approved equal, having minimum density of 3.5 lb. cu. ft. and a maximum "K" factor of 0.22 Btu-in/hr-SF-degrees-F at 50 degrees F mean. Thickness of insulation shall be as follows:

Thickness	Pipe Size
1 inch	Up to 2 inches
1-1/2 inches	2-1/2 inches and over

B. The insulation shall be applied over clean, dry pipe with all joints firmly butted together. Longitudinal laps shall be sealed with Schuller vapor barrier adhesive, Foster or approved equal. Butt joints shall be wrapped with a 4-inch strip of the vapor barrier jacket cemented with vapor barrier adhesive. Each 3 ft. section of insulation and each butt strip shall be additionally secured with 3/4-inch wide Schuller No. 357 white tape, Foster or approved equal.

C. Valve fitting for pipe sizes smaller than 4-inch shall be insulated with Schuller No. 301 Insulating Cement, Foster or approved equal applied in one coat to a thickness equal to the adjoining tape insulation. Fittings for pipe sizes 4-inch and larger shall be insulated with Micro-Lok insulation, Owens-Corning, Certainteed or approved equal securely wired in place, and finished with a leveling coat of Schuller No. 301 Insulating Cement, Foster or approved equal. All fittings regardless of pipe size shall be finished with PVC fitting covers and sealed to maintain vapor barrier.

D. Clamps or hangers in contact with pipe shall be insulated separately in the same manner as fitting. The insulation shall be applied upward along the vertical hanger rod to a point not less than 6 inches and sealed off.

E. Protect pipe insulation at all hanger and support points. Where 1 inch thick insulation is used, it shall be protected by 12 inches long galvanized metal shield. Where 1-1/2-inch insulation is used, 12-inches long section of calcium silicate preformed pipe insulation with a vapor barrier jacket or cellular glass with vapor barrier jacket shall be installed at the hanger point and protected with a 16 gauge galvanized metal shield on the outside of the jacket.

F. Aboveground outdoor pipe insulation for chilled water shall be finished with mastic and reinforcing fabric as recommended by the insulation manufacturer, covered with aluminum jacket, 0.106-inch thick and banded with stainless steel bands.

2.3 OTHER MECHANICAL EQUIPMENT REQUIRING INSULATION

A. Pipe hangers and supports for insulated pipes that contact the pipe surface directly shall be insulated with same insulation system as the pipe insulation.

B. Strainers that are connected to insulated pipes. Insulate strainers with 1-1/2-inch thick cellular glass insulation. Finish insulation with ASJ vapor barrier.

C. Expansion tank that are connected to insulated piping. Insulate tank with 1-1/2-inch thick cellular glass insulation. Finish insulation with ASJ vapor barrier. Provide removable panels

to allow disassembly of strainer (e.g. covers for basket strainers) for routine maintenance without damaging the insulation and vapor barrier.

D. Air separator tanks that are connected to insulated pipes. Insulate separator with 1-1/2-inch thick cellular glass insulation. Finish insulation with ASJ vapor barrier.

E. Flow devices installed in insulated pipes. Insulate with same insulation system as adjacent pipe insulation. Provide removable insulation covers for test connections (e.g. connections to install portable flow meter) of the same material as the pipe insulation.

F. Parts of air handling equipment that are not factory insulated such as mixing boxes, return air plenums, etc. Insulate with same duct insulation system as connecting ductwork.

G. Equipment, pipes and related appurtenances that are indicated or specified to be insulated but were not factory insulated such as duct mounted reheat coils.

H. Insulate all chilled water pumps with 2-inch thick cellular glass insulation, formed into a removable boxed enclosure around the pump with screwed or bolted seams for removal and re-installation of the insulation. No cutting of the insulation or covering shall be required for removal and re-installation of the cover for inspection and maintenance. Provide water resistant, vapor barrier covering. Pump nameplate shall be visible and uncovered.

PART 3 EXECUTION

3.1 COOPERATION WITH OTHER TRADES AND CONFLICT IN WORK

A. Contractor shall examine all drawings of proposed work and coordinate his work with other trades. Work conflicts shall be brought to attention of State and work rearranged or modified in accordance with his decision.

B. If changes in indicated locations or arrangements of work are required, they shall be made by Contractor without additional charge to the State provided that these changes were ordered before work is installed and no extra material or labor are required.

C. Should Contractor determine that extra material and labor will be required to accommodate any rearrangement, he shall first submit detailed estimate of cost for required changes and proceed with work only upon written authority of the Contracting Officer.

3.2 EQUIPMENT INSTALLATION

A. Equipment shall be installed as indicated and in accordance with manufacturer's recommendations and instructions.

B. All necessary supports shall be provided for equipment, appurtenances and duct as required. This work shall include any additional steel purlins, brackets, seismic restraints or supports.

3.3 WORKMANSHIP AND FABRICATION

A. Pipe Insulation: Pipe Insulation (Except Cellular and Calcium Silicate Insulation): Place sections of insulation around pipe and joints tightly butted into place. Draw jacket tight and smooth. Secure jacket with fire resistant adhesive, factory-applied self-sealing lap, or stainless steel outward clinching staples spaced not over 4 inches on center and 1/2 inch minimum from edge of lap. Cover circumferential joints with butt strips, not less than 3 inches wide, of material identical to jacket material. Overlap longitudinal laps of jacket

material not less than 1 1/2 inches. Adhesive used to secure butt strip shall be same as that used to secure jacket laps. Apply staples to both edges of butt strips.

1. Vapor Barrier Jacket: When a vapor barrier jacket is required, as indicated in Table 1, on ends of sections of insulation that butt against flanges, unions, valves, fittings, and joints, provide a vapor barrier coating or manufacturer's weatherproof coating for outside service unless pipe is supplied with factory-applied self-seal lap. Apply vapor barrier coating at longitudinal and circumferential laps. Patch damaged jacket material by wrapping a strip of jacket material around the pipe and cementing, stapling, and coating as specified for butt strips. Extend patch not less than 1 1/2 inches past the break in both directions. At penetrations by pressure gages and thermometers, fill voids with vapor barrier coating for outside service. Seal with a brush coat of the same coating.
2. Roof: Where pipe penetrates, insulate piping to a point flush with top of flashing and seal with vapor barrier coating. Butt top of flashing and interior insulation tightly to exterior insulation. Extend exterior metal jacket 2 inches to fold down beyond end of insulation. Seal flashing and counterflashing underneath with vapor barrier coating.

B. Flexible Cellular Insulation: Bond cuts, butt joints, ends, and longitudinal joints with adhesive. Miter 90-degree turns and elbows, tees, and valve insulation. Where pipes penetrate fire walls, provide mineral-fiber insulation inserts and sheet-metal sleeves. Insulate flanges, unions, valves, and fittings in accordance with manufacturer's published instructions. Apply two coats of finish as recommended by insulation manufacturers to flexible unicellular insulation in outside locations. Do not use vinyl lacquer finish or equivalent. Use metal jackets on cellular insulation located outside.

3.4 PAINTING AND IDENTIFYING OF PIPING

A. General: The following items furnished under this section are to be painted and identified under Section 099000 PAINTING. Do not paint over name plates or other identifying labels.

1. Exposed pipe insulation.
2. Exposed duct insulation.
3. Exposed equipment insulation that is unfinished

3.5 ADJUSTING AND CLEANING

A. Pipes, equipment and ducts shall be cleaned free of scale and thoroughly flushed of all foreign matter prior to field insulation. Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Pipe hangers and supports that were temporarily loosened to allow installation of the insulation, shall be repositioned and adjusted to carry the load without crushing the insulation.

END OF SECTION

SECTION 230923 - DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 GENERAL

1.1 SUMMARY

A. Scope of Work: Central Plant Modifications

B. This section covers the furnishing, fabrication, delivery and installation of a new or addition to an existing direct digital control (DDC) system for the control of the heating, ventilating and air conditioning (HVAC) systems. The DDC system is a multi-loop, stand-alone and distributed digital control system as manufactured by a companies specializing in HVAC controls. The DDC system provides all hardware and software to control of all HVAC control functions including input, logic, processing and output functions. Input functions include analog and digital (binary, on/off, open/close) control signals to the microprocessor based digital controllers.

C. Output is transmitted via interface ports to allow connection to other controllers, terminals, a portable computer or a central site computer. The interface equipment will not provide day to day control of the HVAC system but will allow the operator to enable and disable equipment, changed setpoints, change operating schedules, receive trends and alarms and allows loading and downloading of control programs. The system can communicate with graphic operator work station located in the building (direct connection to a communication LAN) or at a remote site (connected to the digital controller through a LAN, web connection or modems and a telephone line).

D. Related Sections
1. Section 230300 GENERAL MECHANICAL REQUIREMENTS for general mechanical requirements.
2. Division 26 ELECTRICAL for material and installation requirements for control wiring.
3. Division 23 HEATING, VENTILATING, AND AIR CONDITIONING for air conditioning and ventilation equipment being controlled.

1.2 REFERENCES

A. NFPA 70 - \National Electric Code.

B. ASHRAE 135-Data Communication Protocol for Building Automation and Control Networks.

C. UL 916-UL Standard for Safety; Energy Management Equipment

D. ANSI C12.10-Standard for Electromechanical Watthour Meters.

E. ANSI C57.13.2-Standard Conformance Test Procedures for Instrument Transformers

F. SMACNA DCS-Duct Construction Standards

G. ASME B16.5- Pipe Flanges and Flanged Fittings NPS ½ Through NPS 24.

H. ASTM A 126

I. UL 506-UL Standard for Safety Specialty Transformers.

J. UL 1449-UL Standard for Safety Transient Voltage Surge Suppressors

K. NFPA 90A

L. UL 555S-UL Standard for Safety Leakage Rated Dampers for Use in Smoke Control Systems

M. ANSI B40.1- Gauges - Pressure Indicating Dial Type - Elastic Element

1.3 DEFINITIONS

A. BACnet: BACnet is a standard communication protocol under development by the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE). The controller manufacturer shall have a company policy to support the implementation of BACnet.

B. Digital Controller: A control module which is microprocessor based, programmable by the user, has integral I/O, and performs stand-alone operations.

C. Direct Digital Control (DDC): A digital controller as defined in this document. The controller directly senses building environment and makes control decisions based on user defined, controller resident programs. The controller outputs control signals that directly operate valves, dampers, and motor controllers. No conventional control devices, pneumatic or electronic, such as receiver-controllers, thermostats, and logic units are present within or interface with a direct digital control loop. Actuators are electric or pneumatic, and the controller output is converted to the appropriate type of signal.

D. DDC System: A system made up of one or more digital controllers. Required climate control and energy management functions for complete operation of an HVAC system are provided by DDC from digital controllers. No conventional control devices (pneumatic or electronic) such as receiver-controllers, thermostats, and logic units are used. Digital controllers in a system are linked in a communication network composed of one or more levels of local area networks (LAN).

E. Distributed Control: The intent of distributed control is to install the controllers near the equipment being controlled, and to distribute the processing to each stand alone DDC panel. The control system is built up of stand-alone controllers, utilizing sensor inputs and control outputs.

F. Dynamic Control: A process that optimizes operation of HVAC systems (air handler units, converters, chillers, and boilers) by increasing and decreasing setpoints or starting and stopping equipment in response to heating and cooling needs of downstream equipment. A requirement of dynamic control is knowing the heating/cooling demand status of downstream equipment, therefore dynamic control requires controllers connected in a communications network.

G. Firmware: Firmware is software programmed into read only memory (ROM) and erasable programmable read only memory (EPROM) chips. Software may not be changed without physically altering the chip.

H. Graphic Sequence of Operation: A drawing or graphic showing all interlocks and control loop sequences between the input and output points. Graphic sequence of operation is a graphical representation of the sequence of operation. The graphic sequence of operation will show all inputs, outputs, and logic blocks.

I. Hand-Held Terminal: A hand-held terminal is a portable device, control system manufacturer-specific, which can be connected directly to a communications port on a digital

controller and through which the digital controller can be interrogated and, in some cases, programmed.

J. Input/Output (I/O): I/O refers to analog inputs (AI), digital inputs (DI), analog outputs (AO), and digital outputs (DO) in a digital controller. Inputs are from analog sensors (temperature, pressure, humidity, flow) and digital sensors (motor status, flow switches, switch position, and pulse output devices). Outputs operate modulating and on/off control devices.

K. I/O Unit: An I/O unit provides additional point capacity to a digital controller and communicate with the stand-alone digital controller on LAN. An I/O unit is not stand-alone because the control program does not reside in the I/O units microprocessor.

L. Integration: The ability of control system components to have interoperability between different manufacturers to connect together and provide coordinated control via real-time data exchange and control functions through a common communications data exchange protocol. Integration shall extend to the operator's workstation software, which shall support user interaction with all control system components. Methods of integration include industry standard protocols such as: BACnet, ARCnet, LonMark/LonTalk, OLE for Process Control (OPC) or integrator interfaces between cooperating manufacturer's systems.

M. Local Area Network (LAN):
1. A communications bus that interconnects digital controllers for peer-to-peer communications. Different levels of LANs are possible within a single DDC system. In this case a digital controller on a higher level LAN acts as a network controller to the controllers on the lower level LAN. The network controller, then, has at least two LAN communications ports. One port supports peer-to-peer communications with other digital controllers on the higher level LAN. The other port supports communications with the digital controllers on the lower level LAN.
2. LANs permit sharing global information, make it possible to apply building wide control strategies such as peak demand limiting, permit dynamic control strategies, allow coordinated response to alarm conditions, and permit remote monitoring and programming of digital controllers.
3. Facility-wide LAN refers to a commercially available local area network. These LANs allow the connection to an existing or new facility-wide LAN.

N. Microprocessor: A microprocessor refers to the central processing unit (CPU) that contains all the registers and logic circuitry that make it possible for digital controllers to do computing.

O. Open Protocol Bus (OPB): A pre-programmed communications integrator that allows devices from one manufacturer to communicate and interact with those of another.

P. Open System Port (OSP): A user programmable communications port that provides the ability to develop custom communications processes to integrate other operating systems with the DDC System.

Q. Output Signal Conversion: Output signal conversion refers to the changing of one kind of control output into a proportionally related signal appropriate for direct actuation of the controlled device. Signals are converted by a transducer which may be external to the digital controller originating the output.
1. Examples in modulating control of pneumatic actuators are conversion of 4-20 ma signals into proportional 3-15 psig signals.
2. An example of output signal conversion in on/off or open/close control is a contact closure originating in a digital controller which activates a solenoid air valve which passes main air, thereby forcing a damper to open fully.

R. Optimum Start: Optimum start is a method of starting the HVAC equipment prior to occupancy time in order to have the building at setpoint at occupancy. Optimum start shall be based on the zone temperatures, zone setpoints, and outdoor temperature. Optimum start will bring the zone to setpoint at occupancy time.

S. Peer-to-Peer: Peer-to-Peer refers to controllers connected on a communications LAN that act independently, as equals and communicate with each other to pass information which facilitates control.

T. PID: PID refers to proportional, integral, and derivative control; the three types of action that are used in controlling modulating equipment.

U. Resolution: Refers to the number of possible states an input value or output value can take and is a function of the digital controller I/O circuitry; the A/D converter for input and the D/A converter for output. Ten bit resolution has 1024 possible states and eight bit resolution has 256 possible states.

V. Stand-Alone Control: Refers to the digital controller being able to perform required climate control, and energy management functions without connection to another digital controller or central site computer. Digital controller requirements for stand-alone control are a time clock, a microprocessor, microchip resident control programs, PID control, a communications port for interfacing with and programming the controller, firmware for interrogation and programming, and I/O for sensing and effecting control of its control environment.

W. Terminal Control Unit (TCU): An off-the-shelf, stand-alone digital controller equipped for communication on a lower level local area network. TCUs may deviate from stand-alone only in receiving energy management and time information from a stand alone digital controller. A TCU is commonly application specific and is used for distributed control of specific HVAC subsystems. A TCU communicates with the digital controllers. Typically, a TCU communicates on a lower level LAN. Examples where TCUs might be used to control of small air handling units (AHUs), variable air volume (VAV) boxes, fan coil units, and heat pumps.

X. Year 2000 Compliant: Means computer controlled facility components that accurately process date and time data (including, but not limited to, calculating, comparing, and sequencing) from, into, and between the twentieth and twenty-first centuries, and the years 1999 and 2000 and leap year calculations.

1.4 SUBMITTALS

A. Submit in accordance with Section 013300 SUBMITTAL PROCEDURES and Section 230300 GENERAL MECHANICAL REQUIREMENTS:

B. Manufacturer's Catalog Data:
1. DDC hardware
2. DDC capabilities
3. Input devices
4. Output devices
5. Surge and transient protection

C. Equipment and software for which specification compliance data shall be submitted include but not limited to the following:
1. DDC Hardware:

a. I/O; capable of supporting platinum RTD, precision thermistor, 4-20 ma, 0-10 VDC
b. Programs will reside in microprocessor; controllers are stand-alone
c. Communications ports; all communications ports as specified
d. Protected memory; minimum hours required by this specification
e. Operating temperature limits

2. DDC Capabilities:
a. Communications; baud rate, communication ports, stand-alone
b. Trending; capable of trending every point
c. Alarming; capable of alarm generation as indicated
d. Messages; as indicated
e. Self diagnostics; identification of a failed module
f. PID control; capable of PID control

3. Workstation Software: N/A

4. Input Devices:
a. Transmitters; accuracy, 4-20 ma, 0-10 VDC
b. Temperature sensors; accuracy, stability, 100 percent factory screening, platinum RTD or thermistor
c. Humidity sensors; type of sensor, accuracy, range, and stability
d. Pressure sensor; accuracy
e. Flow or motor proof; type
f. Sensor wells; type

5. Output Devices:
a. Dampers; types
b. Valves; types
c. Actuators.
d. Control Relays

6. External Surge and Transient Protection:
a. Power line
b. Communications links and/or devices (between buildings)

7. BACnet Protocol Implementation Statement (PICS) for each controller and operator interface.

D. Drawings: Submit the following drawings:
1. Control system schematic
2. Wiring diagrams and layouts for each control panel.
3. Floor plans indicating field sensor and controller locations.

E. Design Data: Submit test data demonstrating the following installed components will meet specification requirements.
1. Temperature sensor accuracy: Submit manufacturer specification of temperature sensor accuracy. Literature shall make clear sensor accuracy as specified.
2. Temperature sensor stability: Provide manufacturer specification of five year stability of RTDs and thermistors. Literature shall make clear sensor stability as specified.

F. Schedules:
1. List of shop drawings
2. List of symbols and abbreviations used on shop drawings
3. List of I/O points: For each input and output physically connected to a digital controller provide, on a controller by controller basis, provide the following:
a. Point description: for example: mixed air temperature, supply fan start/stop, etc.
b Point type: AO, AI, DO, or DI.
c. Point range: 4-20 ma, 3-15 psi, platinum RTD resistance ohm, thermistor.

d. Sensor range associated with point range: for example 0-100 degrees F, 0-2 inches of water.
e. Software name(s) associated with point, if any.
f. Terminal number to which point is connected.

4. Equipment components list: Submit a listing of controllers and connected devices shown on control system schematic. List the following:
   a. Control system schematic component name
   b. Description
   c. Manufacturer of controller
   d. Controller's name
   e. Equipment part numbers
   f. Cv for valves
   g. For actuators:
      (1) Motive force (such as pneumatic, or electric)
      (2) Normal position
      (3) Nominal operating range (such as 3-7 psi, 4-8 ma)
5. AC power table: Submit a table listing each controller and the circuit breaker number, panel box number, and physical location of each controller's source of AC power.

G. Statements:
1. Contractors' qualifications: Submit statements required in Part 1, Quality Assurance, Qualifications.
2. Training: Submit schedule, syllabus, and training materials in accordance with Part 3, EXECUTION.

H. Records: Provide administrative and closeout submittals:
1. Training course documentation: Training course documentation shall include a manual for each trainee plus two additional copies and two copies of audiovisual training aids, if used. Documentation shall include an agenda, defined objectives for each lesson and detailed description of the subject matter of each lesson.
2. Service organization: Qualified service organization list that shall include the names and telephone numbers of organizations qualified to service the HVAC control systems
3. Contractor certification: Provide certification that the installation of the control system is complete and the technical requirements of this section have been met.

I. Operation and Maintenance Manuals:
1. Controls and HVAC System Operators Manual: Construct and provide a Control and HVAC Systems Operators Manual. This manual is designed to document the HVAC and control system. Construct this manual using a 3 ring binder with a minimum of the following 7 sections. Use tabs to divide each section.
   a. Section 1. Description of HVAC Systems: Provide a description of the HVAC system components and control system. Include sequences of operation and a complete points list.
   b. Section 2. Controls Drawings: Provide drawings as specified.
   c. Section 3. Control Program Listings: Provide listing of all control programs, including terminal equipment controller setup pages.
   d. Section 4. Current Operating Parameters: Provide printouts of input and output setup information, database setups. This section is intended to provide information such as point addresses, slopes and offsets for all points, database of points, etc.
   e. Section 5. Design Information: Provide tab, but leave this section blank.
   f. Section 6. Control Equipment Cut Sheets: Provide cut sheets of all controller hardware and accessories. Include temperature versus resistance charts for temperature sensors, and calibration charts for pressure transducers.

g. Section 7. Control Program: Provide a fully operational control system disk (CD disk format preferred) identical to the original control program as installed. In addition, provide a restore - backup disk of the control program and backup copy of ACAD controls drawings on a 3.5 inch disk. It is understood that the software will be available to the base and used only for the buildings in this contract.

2. DDC Manufacturer's Hardware and Software Manuals
3. Controls and HVAC System Operators Manual:
   a. Section 1. Installation and Technical Manuals for all digital controller hardware.
   b. Section 2. Installation and Technical Manuals for workstations.
   c. Section 3. Operators Manuals for all digital controllers.
   d. Section 4. Operators Manuals for workstations software.
   e. Section 5. Programming Manuals for all digital controllers.
   f. Section 6. Programming Manuals for workstation software.

J. Guarantee and Certificate: Submit one year guarantee and certificate in accordance with Section 230300 GENERAL MECHANICAL REQUIREMENTS.

1.5 QUALITY ASSURANCE

A. General:
1. The Direct Digital Control (DDC) System herein specified shall be fully integrated and installed as a complete package by the Direct Digital Control System Contractor. The System shall include all wiring, piping, installation supervision, calibration, adjustments, and checkout necessary for a complete and fully operational system.
2. The Direct Digital Control System Contractor shall be regularly engaged in the engineering, programming, installation and service of Direct Digital Control systems of similar size and complexity.
3. The DDC Contractor shall have a local facility Oahu. Emergency service shall be available on a 24-hour, 7-day-a-week basis.
4. The DDC Contractor shall be responsible for all work fitting into place in a satisfactory and neat workmanlike manner acceptable to the State.

B. Experience Record:
1. The DDC Contractor shall have a minimum of five years experience with the complete installation of Direct Digital Control systems of similar size and technical complexity. The DDC Contractor shall provide a list of three comparable projects that have Direct Digital Control Systems with the features as specified for this project. These projects must be on-line and functional.
2. The DDC Contractor shall employ specialists in the field of Direct Digital Control Systems including: Programming, Engineering, Field Supervision, and Installation. Specialists shall present factory training certification of the submitted equipment upon request.

C. Governing Code Compliance: The DDC Contractor shall comply with all current governing codes, ordinances and regulations, including UL, NFPA, the local Building Code, NEC, and so forth.

D. FCC Regulation: All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.

E. Standard Products:
1. Materials and equipment shall be standard products of manufacturer regularly engaged in the manufacturing of such products, using similar materials, design and workmanship.

The standard products shall have been in commercial or industrial use for 2 years prior to bid opening. The 2 year use shall include applications of similarly sized equipment and materials used under similar circumstances. The 2 year experience must be satisfactorily completed by a product which has been sold on the commercial market through advertisements, manufacturer's catalogs, or brochures.

2. The equipment items shall be supported by a service organization.

F. Nameplate and Tags:
   1. Nameplates bearing legends as shown and tags bearing device unique identifiers as shown shall be engraved or stamped. Nameplates shall be permanently attached to HVAC control panel doors.
   2. For each field mounted piece of equipment, not in a finished area, a plastic or metal tag with equipment name and point identifier shall be attached.

G. Verification of Dimensions: The contractor shall become familiar with all details of the work, shall verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

H. Drawings: Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, and shall finish all work necessary to meet such conditions.

I. Modification of References: The advisory provision in ASME B31.1 and NFPA 70 shall be considered mandatory. Substitute the work "shall" for "should" wherever it appears and interpret all references to the "authority having jurisdiction" and "owner" to mean the Contracting Officer.

J. Storage: Stored products shall be protected from the weather, humidity and temperature variations, dirt and dust, and other contaminants, within the storage condition limits published by the equipment manufacturer.

1.6 WORK INCLUDED

A. Installation of Direct Digital Control (DDC) System:
   1. The DDC Contractor shall furnish and install a complete Direct Digital Control (DDC) System for all mechanical systems and other facility systems as included in the project documents. The DDC system will provide the functional features as defined in Part 1 - General Requirements, Part 2 - Products, and Part 3 - Execution of these Specifications. The DDC Contractor shall provide a complete and operational system to perform all sequences of operations stated within Part 3 or shown on the control drawings.
   2. The work under this Section shall include all materials and labor to perform all work required for the installation of the DDC as specified.
   3. The drawings and specifications are complementary to one another - meaning that what is called for on one is to be considered called for in both. Where conflicts exists between the specifications and/or drawings, the more stringent requirement shall apply.
   4. The DDC Contractor shall be responsible for field verification of site conditions and for gathering all necessary field data for all items to be provided under this contract prior to submitting his or her bid.
   5. Where work specified under other Sections of this Specification connects to equipment or systems that are listed and described in this Section, the DDC Contractor shall provide proper connection(s) to such equipment including trade coordination.

1.7 COORDINATION

A. Divisions:
   1. The DDC Contractor shall cooperate with other divisions performing work on this project as necessary to achieve a complete and neat installation. The Contractor shall also consult the drawings and specifications of all trades to determine the nature and extent of others' work.
   2. Contractors, Sub-contractors, Employees: It will be the duty of this Contractor to work in cooperation with other contractors, and with other sub-contractors and employees, rendering assistance and arranging his or her work so that the entire project.

1.8 MANUALS

A. All manuals shall be provided in hard copy format or on a single Compact Disk (CD) as part of an on-line documentation system through the operator workstation.

PART 2 PRODUCTS

2.1 GENERAL

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135-2004, BACnet.

B. Install new wiring and network devices as required to provide a complete and workable control network.

C. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.
   1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.
   2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies indicated. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

E. Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated controller via the internetwork.

F. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

2.2 SYSTEM ARCHITECTURE

A. Web Based System: DDC system shall be web-based and include a web server, workstation and controllers which communicate using the BACnet protocol. The web server or

workstation and control network backbone shall communicate using BACnet /IP addressing as specified in ASHRAE 135-2004, BACnet Annex J.

B. First Tier Network:
   1. The first tier network shall be based on a PC industry standard of Ethernet TCP/IP, or ARCnet. PC Workstation LAN controller cards shall be standard "off the shelf" products available through normal PC vendor channels.
   2. The DDC system shall network multiple operator workstations, network controllers, system controllers, and application-specific controllers. The first tier network shall provide communications between operator workstations and first tier DDC (Direct Digital Control) controllers.
   3. The first tier network shall operate at a minimum communication speed of 2.5 M baud, with full peer-to-peer network communication.
   4. Network Controllers shall reside on the first tier.

C. First Tier Network Protocol Integration: A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BACnet system devices.

D. Second Tier Network:
   1. The second tier network is used to communicate between the first tier DDC controllers and field controllers.
   2. Second tier networks shall utilize either "Peer-to-Peer," Master-Slave, or Supervised Token Passing communications.

E. Second Tier Controller Protocol Integration:
   1. Hardwired:
      a. Analog and digital signal values shall be passed from one system to another via hardwired connections.
      b. There will be one separate physical point on each system for each point to be integrated between the systems.
      c. Analog points will be 4-20 mA signals originating at the "from system" and being received by the "to system".
      d. Digital points will be "dry contact" signals originating at the "from system" and being received by the "to system."
   2. Direct Protocol:
      a. The DDC system shall include appropriate hardware equipment and software to allow data communications between the DDC system and 3rd party manufacturers control panels. The DDC shall receive, react to, and return information from multiple building systems, variable frequency drives, power monitoring systems, etc.
      b. All data required by the application shall be mapped into the First Tier Network DDC Controller's database, and shall be transparent to the operator.
      c. Point inputs and outputs from the third-party controllers shall have real-time interoperability with DDC software features such as: Control Software, Energy Management, Custom Process Programming, Alarm Management, Historical Data and Trend Analysis, Totalization, and Dial-Up and Local Area Network Communications.
      d. Integration shall be via RS-232 or RS-485 technologies.
      e. The system operator shall have the ability to verify, and diagnose communication messages and point information between third-party controllers and the DDC system.

2.3 DDC SYSTEM

A. Provide a DDC system as a distributed control system. The system shall have stand- alone digital controllers, a communications network and a separate workstation computer with workstation software.

B. Provide an operator programmable system, based on the user applications, to perform closed-loop, modulating and/or on-off control of building equipment. Connect all digital controllers through the communication network to share common data and report to workstation computers. The workstation computers will be capable of being programmed to supervise the digital controllers. The control system shall be capable of down-loading and up-loading of programs between the workstation and the digital controllers.

C. Provide the quantity of digital controllers indicated on the drawings that will perform required climate control, energy management, and alarm functions. The quantity of controllers shall be no less than the number shown on drawings. All material used shall be currently in production.

1. Direct Digital Controllers: DDC hardware shall be UL 916 rated.
    a. Distributed Control: Apply digital controllers in a distributed control manner.
    b. Environmental Operating Limits: Provide digital controllers that operate in environmental conditions between 32 and 120 degrees Fahrenheit.
    c. Memory:
        (1) Provide sufficient memory for each controller to support required control and communication functions.
        (2) Memory Protection: Programs residing in memory shall be protected either by using EEPROM or by an uninterruptible power source (battery or uninterruptible power supply (UPS)). The backup power source shall have sufficient capacity to maintain volatile memory in event of an AC power failure. Where the uninterruptible power source is rechargeable (a rechargeable battery), provide sufficient capacity for a minimum of seventy-two hours back-up. The rechargeable power source shall be constantly charged by charging circuitry while the controller is operating under normal line power. Where a nonrechargeable power source is used, provide sufficient capacity for a minimum of two years accumulated power failure. Batteries shall be designed to allow replacement without soldering.
    d. Inputs: Provide input function integral to the direct digital controller. Provide input type as required by the DDC design.
        (1) Analog Inputs: Allowable input types are three wire 100 ohm or higher platinum RTD's, stable 10,000 ohm thermistors, 0-10 VDC and 4 to 20 ma. Thermistor and direct RTD inputs must have appropriate conversion curves stored in controller software or firmware. Analog to digital (A/D) conversion shall be a minimum of 10 bit resolution.
        (2) Digital Inputs: Digital inputs shall sense open/close, on/off, or other two state indications.
    e. Outputs: Provide output function integral to the direct digital controller. Provide output type as required by the DDC design. Insure that the output of controllers are compatible with controlled devices.
        (1) Analog Outputs: Provide controllers with a minimum output resolution of 8 bits. Output shall be 4 to 20 ma or 3 to 15 psi or 0-10 VDC. Each pneumatic output shall have feedback for monitoring of the actual pneumatic signal. Feedback shall be integral to the output function.
        (2) Digital Outputs: Provide contact closure with contacts rated at a minimum of 1 ampere at 24 volts.

f. PID Control: Provide controllers with proportional, proportional plus integral, and proportional plus integral plus derivative control capability. Terminal controllers are not required to have the derivative component.

g. Communications Ports:

(1) Controller-to-Controller LAN Communications Ports: Controllers in the building DDC system shall be connected in a communications network. Controllers shall have controller to controller communication ports to both peer controller (lower level controller). Network may consist of more than one level of local area network and one level may have multiple drops. Communications network shall permit sharing between controllers of sensor and control information, thereby allowing execution of dynamic control strategies and coordinated response to alarm conditions.

(2) On-Site Interface Ports: Provide a RS-232, RS-485, or RJ-11, or RJ-45 communications port for each digital controller that allows direct connection of a computer or hand held terminal and through which the controller may be fully interrogated. Controller access shall not be limited to access through another controller. On-site interface communication ports shall be in addition to the communications port(s) supporting controller to controller communications. Communication rate shall be 56K Baud minimum. Every controller on the highest level LAN shall have a communications port supporting direct connection of a computer; a hand held terminal port is not sufficient. By connecting a computer to this port, every controller in the direct digital control system shall be able to be fully interrogated and programmed. The following operations shall be available: downloading and uploading control programs, modifying programs and program data base, and retrieving or accepting trend reports, status reports, messages, and alarms.

(3) Remote Work Station Interface Port: Provide one additional direct connect computer port in each DDC system for permanent connection of a remote operator's workstation, unless the workstation is a node on the LAN. All operations possible by directly connecting a computer to a controller at the highest level LAN shall be available through this port.

(4) Telecommunications Interface Port: Provide one additional telecommunications port in each DDC system permitting remote communications via telephone. All operations possible by directly connecting a computer to a controller at the highest level LAN shall be available through the telecommunications port. A telecommunications port provided on a digital controller shall be in addition to the port required for directly connecting a computer to the controller. Telecommunication baud rate shall be 96K minimum.

h. Modem: Provide one modem per DDC system to communicate between the digital control system and the workstation.

i. Digital Controller Cabinet: Each digital controller cabinet shall protect the controller from dust and be rated NEMA 1, unless specified otherwise.

(1) Controller cabinets, or enclosures the controller's is mounted in shall be provided with a lock.

j. Main Power Switch: Each controller on the highest level LAN shall have a main power switch for isolation of the controller from AC power. The switch shall be protected from tampering within the DDC cabinet.

k. DDC system shall be web-based and include controllers which communicate using the BACnet protocol. The control network backbone shall communicate using BACnet /IP addressing as specified in ASHRAE 135-2004, BACnet Annex J.

l. Building Controllers:

(1) Building controllers shall conform to BACnet Building Controller (B-BC) device profile as specified in ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-BC in the BACnet Testing laboratories (BTL) Product Listing.
(2) Digital Controller Networking Capabilities: The upper level digital controllers shall be capable of being networked with other similar upper level controllers. Upper level controllers shall also be capable of communicating over a network between buildings.
(3) Internal Clock: Provide clock with each controller on the first tier local area network (LAN) and shall have its clock backed up by a battery or capacitor with sufficient capacity to maintain clock operation for a minimum of 72 hours during a line power outage.

m. Terminal Control Unit Controllers:
(1) Advanced Application controllers shall conform to BACnet Building Controller (B-AAC) device profile as specified in ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing laboratories (BTL) Product Listing.
(2) Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.
(3) TCU controllers shall be manufactured by the same company as the digital controllers.
(4) TCU controllers shall automatically start-up on return of power after a failure, and previous operating parameters shall exist or shall be automatically downloaded from a digital controller on a higher level LAN.
(5) TCU controllers do not require an internal clock, if they get time information from the digital controller.

n. BACnet Communication:
(1) Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.
(2) BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
(3) Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
(4) Each ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

2. DDC Software: Software resides in the digital controllers and performs control sequences.
a. Sequence of Control: Provide, in the digital controllers, software to execute the sequence of control. Provide sequences of control written in both text or graphic format.
b. Database Modification: Provide software to modify the control program database. Database modification shall be accomplished through connected computer or hand held terminal or through a keypad integral to the controller. Database modification shall be accomplished without having to make changes directly in line-by-line programming. As a result of this requirement, when the control program is of the line-by-line type, database parameters in the following list that take real number values shall require assignment of variable names so parameters can be changed without modifying the line-by-line programming. Alternatively, block programming languages shall provide for modification of these database

parameters in fill-in-the-blank screens. The following shall be modifiable in this way:

(1) Setpoints
(2) Deadband limits and spans
(3) Reset schedules
(4) Switchover points
(5) PID gains and time between control output changes
(6) Time
(7) Timed local override time
(8) Occupancy schedules
(9) Holidays
(10) Alarm points, alarm limits, and alarm messages
(11) Point definition database
(12) Point enable, disable, and override
(13) Trend points, trend intervals, trend reports
(14) Analog input default values
(15) Passwords
(16) Communications parameters including network and telephone communications setups

c. Differential: Where equipment is started and stopped or opened and closed in response to some analog input such as temperature, pressure, or humidity, include a differential for the control loop to prevent short cycling of equipment.

d. Motor and Flow Status Delay: Provide an adjustable delay between when a motor is commanded on or off and when the control program looks to the motor or flow status input for confirmation of successful execution of the command.

e. Runtime Accumulation: Provide resettable run time accumulation for each controlled electrical motor.

f. Timed Local Override: Provide user definable adjustable run time for each push of a momentary contact timed local override. Pushes shall be cumulative with each push designating the same length of time. Provide a user definable limit on the number of contact closures summed, such as 6, before the contact closures are ignored. Timed local overrides are to be disabled during occupancy periods.

g. Time Programs: Provide programs to automatically adjust for leap years, and make daylight savings time and standard time adjustments.

h. Scheduling:

(1) Each control output point shall be adjustable for selection of operation based on time of day, day of week, and day of year. Output points may be associated into groups. Each group may be associated with a different schedule. Changing the schedule of a group shall change the schedule of each point in the group. Points may be added to and deleted from groups. Groups may be created and deleted by the operator.
(2) Provide capability that will allow current schedules to be viewed and modified in a seven day week format. When control program does not automatically compute holidays, provide capability to allow holiday schedules to be entered one full year at a time.

i. Point Override: I/O and virtual points shall be able to be software overridden in the software and commanded to any possible value from the main building digital controller.

j. Alarming: I/O points and virtual points shall be alarmable. Alarms may be enabled and disabled for every point. Alarm limits shall be adjustable on analog points. Controllers connected to an external communications device such as a printer, terminal, or computer, shall download alarm and alarm message when alarm occurs. Otherwise alarms will be stored and automatically downloaded when a communications link occurs. The following conditions shall generate alarms:

(1) Motor is commanded on or off but the motor status input indicates no change
(2) Room temperature, humidity, or pressure strays outside selectable limits
(3) An analog input takes a value indicating sensor failure
(4) A module is "dead" to the LAN
(5) A power outage occurs

k. Messages: Messages shall be operator defined and assigned to alarm points. Messages shall be displayed when a point goes into alarm.

l. Trending: DDC system shall have the capability to trend I/O and virtual points. Points may by associated into groups. A trend report may be set up for each group. The period between logging consecutive trend values shall range from one minute to 60 minutes at a minimum. Trend data type shall be selectable as either averages over the logging period or instantaneous values at the time of logging. The minimum number of consecutive trend values stored at one time shall be 30 per variable. When trend memory is full, the most recent data shall overwrite the oldest data. Trend data shall be capable of being uploaded to computer. Trend data shall be available on a real time basis; trend data shall appear either numerically or graphically on a connected computer's screen as the data being processed from the DDC system data environment. Trend reports shall be capable of being uploaded to computer disc and archived.

m. Status Display: Current status of I/O and virtual points shall be displayed on command. Points shall be associated into functional groups, such as all the I/O and virtual points associated with control of a single air handling unit, and displayed as a group, so the status of a single mechanical system can be readily checked. A group shall be selectable from a menu of groups having meaningful names; such as AHU-4, Second Floor, Chiller System, and other such names.

n. Diagnostics: Each controller shall perform self-diagnostic routines and provide messages to an operator when errors are detected. DDC system shall be capable of recognizing a nonresponsive module on a LAN. The remaining, responsive modules on a LAN shall not operate in a degraded mode.

o. Power Loss: In event of a power outage, each controller shall assume a disabled status and outputs shall go to an user definable state. Upon restoration of power, DDC system shall perform an orderly restart, with sequencing of outputs.

p. Program Transfer: Provide software for download of control programs and database from a computer to controllers and upload of same to computer from controllers. Every digital controller in the DDC system shall be capable of being downloaded and uploaded to through a single controller on the highest level LAN.

q. Password Protection: Provide at least three levels of password protection to the DDC system permitting different levels of access to the system.

r. Energy Data Recording: Provide a resettable signal accumulation for each meter at the main building digital controller.
(1) Calculate chilled water thermal energy in BTU/HR using chilled water supply temperature and flow and chilled water return temperature signals.
(2) Record electrical energy in KWH and electrical demand in KW.

s. Remote Communication: System shall automatically contact operator workstation or server on receipt of critical alarms. If no network connection is available, system shall use a modem connection.

t. Maintenance Management: System shall generate maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits.

u. Staggered Start: System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust computer restart order and time delay between equipment restarts.

3. Operator Interface:
a. Provide an operator interface or web server and software installed to provide an interface for monitoring, troubleshooting, and making adjustments to the program

or operating parameters of the DDC system from a central location. Operator interface shall be a PC based workstation that resides on the high-speed network with the building controllers. Web server or workstation and controllers shall communicate using BACnet protocol. Web server or workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ANSI/ASHRAE 135-2004, BACnet Annex J.

b. Hardware: All workstation or server computer hardware equipment and peripherals shall be recommended by the DDC system manufacturer. The workstation shall be configured to operate according to the DDC system manufacturer's specifications. Workstation hardware shall be configured to allow operation of software, uploading and downloading of programs, and creation of graphics. At a minimum the workstation hardware shall consist of:

1) Workstation
   2.26 GHz Core 2 Duo or higher processor
   80 GB SATA 7200 rpm minimum
   2 GB, DDR2 SDRAM minimum
   Enhanced IDE (EIDE) controller
   48X/32X CD-RW/DVD Combo drive
   Graphics card 256 MB PCIe x 16
   10/100 BT Network Interface card
   USB Quietkey Keyboard
   Flash BIOS, PnP 1.0a, PCI BIOS 2.1, DMI 2.0 compliant, Y2K compliant
   Pre installed Windows XP Professional
   Microsoft Office Professional
   Virus scanner program with 3 year subscription for updates
   Soundblaster compatible audio with speakers (internal)
   Flat screen CRT 17 inch monitor (<0.28 mm Dot Pitch & 0.25Aperture Grill Pitch, 1024x768 at Non-Interlaced 85 Hz or greater, Plug and Play Compatible, Energy Star Compliant
   Y2K Compliant
   DMI 2.0 compliant
   Three (3) year warranty
   Warranty Label
   On-line Asset Reporting
   OEM or Contractor provided CD-ROM containing software (i.e. operating system/application software) provided on hard drive at time of purchase
   OEM or Contractor provides user's manual for each type of hardware
   2 button scroll mouse
   56 K PCI Fax Modem
   Printer; laser with one (1) year warranty
   110 volt terminal strip with surge protection and UPS
   Computer cart or table and chair"

c. Software: Workstation software shall be recommended and supported by the DDC system manufacturer and configured to operate according to the DDC system manufacturer's specifications. Workstation software shall permit monitoring and troubleshooting of the DDC system. Workstation software permits modification of the controller database and control programs. Operations shall be menu selected. Menu selections shall be made with a mouse.

(1) Menu System: Menu system shall allow an operator to select a particular function or access a particular screen through successive menu penetration.

(2) Controller Data Base Modification: The workstation software shall be an interface for performing capabilities specified in paragraph entitled "DDC

Software" and available through direct connection of a computer to a digital controller. Database modification shall require only that an operator "fill in the blank" for that parameter on a screen requesting the information in plain language. Database modifications shall be automatically downloaded to the appropriate controllers at operator request.

(3) Program modification: For systems using a line-by-line programming language, provide an off-line text editor, similar to BASIC program editor, permitting modification of controller resident control programs. For systems using block programming languages provide a capability for linking blocks together to create new programs or modify existing programs. Program modifications shall be automatically downloaded to the appropriate controllers at operator request.

d. Graphic-Based Software: The intent of graphic-based software is to provide an ergonomic interface to the DDC system that encourages effective and efficient interaction with the system. Graphic-based software shall provide graphical representation of the building, the buildings mechanical systems, and the DDC system. The current value and point name of every I/O point shall be shown on at least one graphic and in its appropriate physical location relative to building and mechanical systems.

(1) Graphics shall closely follow the style of the control drawings in representing mechanical systems, sensors, controlled devices, and point names.

(2) Graphic Title: Graphics shall have an identifying title visible when the graphic is being viewed.

(3) Dynamic Update: When the workstation is on-line with the control system, point data shall update dynamically on the graphic images.

(4) Graphic Penetration: Provide graphic penetration when the capability exists. For systems without graphic penetration, provide menu penetration for selection of individual graphics to give the same hierarchical affect provided by graphic penetration.

(5) Graphic Types: Graphic-based software shall have graphics of the building exterior, building section, floor plans, and mechanical systems. Provide the following graphics:

(a) Building Exterior Graphic: Show exterior architecture, major landmarks, and building number.

(b) Building Section Graphic: Show stacked floors in section graphic with appropriate floor name on each floor.

(c) Floor Plan Graphics: Provide a single graphic for each floor, unless the graphic will contain more information that can reasonably be shown on a single graphic. Each heating or cooling zone within a floor plan shall have a zone name and its -current temperature displayed within the zone outline. Show each controlled variable in the zone. Provide visual indication for each point that is in alarm.

(d) Mechanical System Graphics: Provide two-dimensional drawings to symbolize mechanical equipment; do not use line drawings. Show controlled or sensed mechanical equipment. Each graphic shall consist of a single mechanical system; examples are a graphic for an air handling unit, a graphic for a VAV box, a graphic for a heating water system, and a graphic for a chiller system. Place sensors and controlled devices associated with mechanical equipment in their appropriate locations. Place point name and point value adjacent to sensor or controlled device. Provide visual indication of each point in alarm. Condition, such as zone temperature, associated with the mechanical system shall be shown on the graphic. Point values shall update dynamically on the graphic.

(i) Graphic Editing: Full capacity as afforded by a draw software package shall be included for operator editing of graphics. Graphics may be created, deleted, and modified, and text added. Provide capability to store graphic symbols in a symbol directory and incorporate these symbols into graphics. A minimum of sixteen colors shall be available.

(ii) Dynamic Point Editing: Provide full editing capability for deleting, adding, and modifying dynamic points on graphics.

(iii) Trending: Trend data shall be displayed graphically, with control variable and process variable plotted as functions of time one the same chart. Graphic display of trend data shall be a capability internal to the workstation software and not a capability resulting from download of trend data into a third-party spreadsheet program such as Lotus, unless such transfer is automatic and transparent to the operator, and the third-party software is included with the workstation software package. At the operator's discretion trend data shall be plotted real time.

4. Maintenance Personnel Interface Tools: Provide a notebook computer for field communication with the digital controllers. In addition to changing setpoints, and making operational changes, field personnel shall be able to upload and download programs with the notebook computer. Provide graphic software as indicated for Operator Interface.
   a. Provide laptop computer, necessary software, and direct connection cable to communicate with the digital controllers when directly connected.
      (1) 2.28 GHz Core 2 Duo processor or higher
      2.0 GB DDR3-1066 MHz SDRAM
      17" WXZGA color LCD display
      80 GB SATA, 5400 RPM
      PnP, Y2K compliant
      Windows XP Professional
      2 PCMCIA slots (1 type I or 1 type II)
      8X DVD +/- RW
      Integrated 56K modem
      10/100 BT Network Interface Card
      Graphics accelerator with 512 MB of video memory
      9 pin serial connector, 25-pin parallel connector
      2 universal serial bus, 2.0 compliant, 4 pin connectors
      9 cell "Smart" lithium-ion battery, 72 WHr minimum
      Battery charger and AC adapter
      Three year warranty"

   b. Recommended by the digital controller manufacturer with a direct connection cable to communicate with the digital controller.

2.4 SENSORS AND INPUT HARDWARE

A. Field Installed Temperature Sensors:
   1. Thermistors: Precision thermistors may be used in temperature sensing applications below 200 degrees F. Sensor accuracy over the application range shall be 0.36 degree F or less between the range of 32 to 150 degrees F. Sensor manufacturer shall utilize 100 percent screening to verify accuracy. Thermistors shall be pre-aged, and inherently stable. Stability error of the thermistor over five years shall not exceed 0.25 degree F cumulative. Sensor element and leads shall be encapsulated. Bead thermistors are not

allowed. A/D conversion resolution error shall be kept to 0.1 degree F. Total error for a thermistor circuit shall not exceed 0.5 degree F, which includes sensor error and digital controller A/D conversion resolution error. Provide thermistor and digital controller manufacturer documentation and the Contractor's engineering calculations which support the proposed thermistor input circuit will have a total error of 0.5 degree F or less. Provide 18 gage twisted and shielded cable for thermistors.

2. Resistance Temperature Detectors (RTDs): Provide RTD sensors with 1000 ohm, or higher, platinum element that are compatible with digital controllers. Sensors shall be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper. Temperature sensor accuracy shall be 0.1 percent (1 ohm) of expected ohms (1000 ohms) at 32 degrees F. Temperature sensor stability error over five years shall not exceed 0.25 degree F cumulative. Direct connection of RTDs to digital controllers, without transmitters, is preferred provided controller supports direct connection of RTDs. When RTDs are connected directly to the controller, keep lead resistance error to 0.25 degree F or less. Provide 3 wire sensing circuits to not exceed the 0.25 degree F lead resistance error. Total error for a RTD circuit shall not exceed 0.5 degree F, which includes sensor error, lead resistance error or 4 to 20 milliampere transmitter error, and A/D conversion resolution error. Provide manufacturer documentation and the Contractor's engineering calculations which support the proposed RTD circuit will have a total error of 0.5 degree F or less for the specified application.
    a. Wiring: Provide 18 gage twisted and shielded pair cable for direct connected RTDs. Provide 18 gage twisted and shielded pair cable for RTDs using 4 to 20 milliampere transmitters.
    b. Transmitters: Provide 4 to 20 milliampere transmitters for RTDs where Digital controllers do not support direct connection of RTDs to controllers; Digital controllers do not meet temperature resolution requirement of 0.5 degree F.
3. Temperature Sensor Details:
    a. Room: Conceal element behind protective cover matched to the room interior. Room temperature sensor shall have integral pushbutton, digital input to the controller for system override, and a setpoint adjustment, analog input to the controller. Digital sensors that communicate directly with the terminal control unit are acceptable. Provide a connection to allow interrogation of the digital controller.
    b. Duct Averaging Type: Continuous averaging RTDs for ductwork applications shall be 1 foot in length for each 4 square feet of ductwork cross-sectional area with a minimum length of 6 feet. Probe type duct sensors of one foot length minimum are acceptable in ducts 12 feet square and less.
    c. Immersion Type: 3 inches and 6 inches where needed total immersion for use with sensor wells, unless otherwise indicated.
    d. Sensor Wells: Brass materials; provide thermal transmission material compatible with the immersion sensor. Provide heat-sensitive transfer agent between exterior sensor surface and interior well surface.
    e. Outside Air Type: Provide element on the buildings north side with sunshade to minimize solar effects. Mount element at least 3 inches from building outside wall. Sunshade shall not inhibit the flow of ambient air across the sensing element. Shade shall protect sensing element from rain.

B. Transmitters: Transmitters shall have 4 to 20 ma, or 0-10 VDC output linearly scaled to the temperature, pressure, humidity, or flow range being sensed. Transmitter shall be matched to the sensor, factory calibrated, and sealed. Total error shall not exceed 0.1 percent of 20 milliampere (0.02 milliampere) at any point across the 4 to 20 ma span. Supply voltage shall be 24 volts ac or dc. Transmitters shall have non-interactive offset and span adjustments. For temperature sensing, transmitter stability shall not exceed 0.05 degree F a year.
    1. Spans and Ranges: Transmitter spans or ranges shall be the following and shall be suitable for the application:

a. Temperature:
   (1) 50 degree F span: Room, chilled water, cooling coil, discharge air, return air sensors.
   (2) 100 degree F span: Outside air, hot water, heating coil discharge air, mixed air sensors.
   (3) 200 degree F span: High temperature hot water, heating hot water, chilled/hot water system sensors.
b. Pressure:
   (1) 0 to 100 psi differential: Water differential range
   (2) 0 to 5 inches water range: Duct static pressure

C. Relative Humidity Transmitters: Provide integral humidity transducer and transmitter. Output of relative humidity instrument shall be a 4 to 20 milliampere or 0 to 10 VDC signal proportional to 0 to 100 percent relative humidity input. Accuracy shall be 2 percent of full scale within the range 20 to 80 percent relative humidity. Sensing element shall be chilled mirror type, polymer, or thin film polymer type. Supply voltage shall be 24 VDC. Transmitter shall meet specified requirements.

D. Pressure Transmitters: Provide integral pressure transducer and transmitter. Output of pressure instrument shall be a 4 to 20 milliampere or 0 to 10 VDC signal proportional to the pressure span. Span shall be as specified. Accuracy shall be 1.0 percent. Linearity shall be 0.1 percent. Supply voltage shall be 24 VDC. Transmitter shall meet specified requirements.

E. Current Transducers: Provide current transducers to monitor amperage of motors. Select current transducer range for normal amperage to be above 50 percent of the range. Current transducers shall have an accuracy of 1 percent and a 4 to 20 milliampere output signal.

F. Input Switches:
1. Differential Static Pressure Switch: Provide diaphragm type differential static pressure switches for binary (two position) operation as specified in sequence of operation. Devices shall withstand pressure surges up to 150 percent of rated pressure. Contacts shall be single pole double throw and switch may be wired for normally open or normally closed operation. Trip set point shall be adjustable. Pressure switch shall be sized so that operating pressure trip point is approximately midpoint of pressure switch adjustable range. Repetitive accuracy shall be 2 percent.
2. Induced Current Operated Solid State Switches: Provide adjustable ranging to monitor continuous loads up to 200 amperes. Switch shall indicate whether it is normally open or normally closed. Limit off-state leakage to 2 milliampere or less.
3. Timed Local Override: Provide momentary contact push button override with override time set in controller software. Provide to override DDC time of day program and activate occupancy program for assigned units. Upon expiration of override time, the control system shall return to time-of-day program. Time interval for the length of operation shall be software adjustable and shall expire unless reset.

2.5 OUTPUT HARDWARE

A. Damper: Damper shall conform to SMACNA DCS.
1. A single damper section shall have blades no longer than 48 inches and shall be no higher than 72 inches. Maximum damper blade width shall be 8 inches. Larger sized damper shall be made from a combination of sections.
2. Dampers shall be steel, or other materials where shown. Flat blades shall be made rigid by folding the edges. Blades shall be provided with compressible seals at points of contact. The channel frames of the dampers shall be provided with jamb seals to minimize air leakage. Dampers shall not leak in excess of 20 cfm per square foot at 4

inches water gage static pressure when closed. Seals shall be suitable for an operating temperature range of minus 40 degrees F to 200 degrees F. Dampers shall be rated at not less than 2000 fpm air velocity. All blade-connecting devices within the same damper section will not be located directly in the air stream. Damper axles shall be 0.5 inch (minimum) plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically shall be supported by thrust bearings. Pressure drop through dampers shall not exceed 0.04 inch water gage at 1000 fpm in the wide open position. Frames shall not be less than 2 inches in width. Dampers shall be tested in accordance with AMCA 500.

3. Operating links external to dampers (such as crankarms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers) shall withstand a load equal to twice the maximum required damper-operating force. Rod lengths shall be stainless steel. Working parts of joints and clevises shall be brass, bronze, or stainless steel. Adjustments of crankarms shall control the open and closed position of dampers.

B. Control Valves:

1. Valve Assembly: Valves shall have stainless steel stems. Valve bodies shall be designed for not less than 125 psig working pressure or 150 percent of the system operating pressure, whichever is greater. Valve leakage rating shall be 0.01 percent of rated Cv. Class 125 copper alloy valve bodies and Class 150 steel or stainless steel valves shall conform to ASME/ANSI B16.5 as a minimum. Cast iron valve components shall conform to ASTM A 126 Class B or C as a minimum.
2. Butterfly Valve Assembly: Butterfly valves shall be threaded lug type suitable for dead-end service and for modulation to the fully closed position, with noncorrosive discs, stainless steel shafts supported by bearing, and EPDM seats suitable for temperatures from minus 20 degrees F to plus 250 degrees F. Valves shall have a manual means of operation independent of the actuator.
3. Two-Way Valves: Two-Way valves shall have equal percentage characteristics.
4. Three-Way Valves: Three-Way valves shall have equal percentage characteristics.
5. Valves for Chilled Water Service: Bodies for valves 1-1/2 inches and smaller shall be brass or bronze, with threaded or union ends. Bodies for valves from 2 inches to 3 inches inclusive shall be of brass, bronze or iron. Bodies for 2 inch valves shall have threaded ends. Bodies for valves from 2-1/2 to 3 inches shall have flanged-end connections. Internal valve trim shall be brass or bronze except that valve stems may be Type 316 stainless steel. Water valves shall be sized for a 3 psi differential through the valve at rated flow, except as indicated otherwise. Select valve flow coefficient (Cv) for an actual pressure drop not less than 50 percent or greater than 125 percent of the design pressure drop at design flow. Valves 4 inches and larger shall be butterfly valves.

C. Actuator: Provide electric type with spring return so that, in the event of power failure, actuators shall fail safe in either the normally open or normally closed position as specified. Actuators shall be quiet operating and function properly within the range of 85 to 110 percent of the motive power. Provide a minimum of one actuator for each damper.

1. Electric Actuators: Provide direct drive electric actuators for all damper control applications. When operated at rated voltage, each operator shall be capable of delivering the torque required for continuous uniform movement of the valve or damper and shall have end switch to limit travel or shall withstand continuous stalling without damage. Operators shall function properly with range of 85 to 110 percent of line voltage. Provide gears of steel or copper alloy. Fiber or reinforced nylon gears may be used for torques less than 16 inch pounds. Provide hardened steel running shafts in sleeve bearing of copper alloy, hardened steel, nylon, or ball bearing. Provide two-position operators of the single direction, spring return, or reversing type. Provide proportioning operators capable of stopping at all points in the cycle and starting in either direction, from any point. Provide reversing and proportioning operators with limit

switches to limit travel in either direction unless operator is stall type. Equip valve operators with a force limiting device such as spring yield so that, when in a relaxed position, device shall maintain a pressure on valve disc equivalent to system pressure at valve. Provide reversible shaded pole, split capacitor, synchronous, or stepped type electric motors. Provide actuator with NEMA 4 actuator housing.

D. Output Switches:
   1. Control Relays: Shall be double pole, double throw (DPDT), UL listed, with contacts rated to the application, and enclosed in a dustproof enclosure. Equip with a light indicator which is lit when coil is energized and is off when coil is not energized. Relays shall be socket type, plug into a fixed base, and be replaceable without need of tools or removing wiring.

2.6 ELECTRICAL POWER AND DISTRIBUTION

A. For control power provide a new, 120 volts or less, 60 Hz, two-pole, three wire (black, white and green) circuit. Run green ground wire to panel ground. Conduit grounding will not be accepted.

B. Transformers: Transformers shall conform to UL 506. Power digital controllers and digital controllers serving terminal control units shall be fed from dedicated circuit breakers with surge protection specified. Transformers for digital controllers serving terminal equipment on lower level LANs may be grouped to have specified surge protection sized for the number of controllers on a single transformer. Provide a fuse cutout on the secondary side of the transformer.

C. Surge Protection: Surge and transient protection consist of devices installed externally to digital controllers.
   1. Power Line Surge Protection: Surge suppressors external to digital controller, shall be installed on all incoming AC power. Surge suppressor shall be rated by UL 1449, and have clamping voltage ratings below the following levels:
      a. Unit is a transient voltage surge suppressor (TVSS) 120VAC/single phase/2wire plus ground. Hard wire individual equipment protector.
      b. Unit must react with 5 nanoseconds and automatically reset.
      c. Voltage protection threshold, line to neutral, starts at no more than 21 volts peak on the 120 VAC line.
      d. TVSS must have an independent secondary stage equal to or greater than the primary stage joule rating.
      e. The primary suppression system components must be pure Silicon Avalanche Diodes.
      f. Silicon Avalanche Diodes (SAC) or Metal Oxide Varistors (MOV) are acceptable in the independent secondary suppression system.
      g. The Transient Suppression System shall incorporate an indicating light which denotes whether the primary and/or secondary transient protection components is/are functioning.
      h. All system functions of the Transient Suppression System must be individually fused and not short circuit the AC power supply at any time.
      i. The Transient Suppression System shall incorporate an EMI/RFI noise filter with a minimum attenuation of 13 db at 10 kHz to 300 MHz.
      j. The system must comply with IEEE C52.41, Class “B” requirement and be tested according to IEEE C62.45.
      k. The system shall operate at -20 degrees C to +50 degrees C.
   2. Telephone and Communication Line Surge Protection: Provide transient surge protection to protect the DDC controller and LAN related devices from surges that occur on the

phone lines (modem and direct connect) and on inter-unit LAN communications. Devices shall be UL listed.

a. The surge protection shall be a rugged package with continuous, non-interrupting protection and not use "crowbar" circuiting. Instant automatic reset after safely eliminating transient surges, induced lightning and other forms of transient over voltages.
b. Unit must react within 5 nanoseconds using only solid-state silicon avalanche technology.
c. Unit shall be installed at the proper distance within system as recommended by the manufacturer.

3. Controller Input/Output Protection: Controller input/output points shall be surge protected with optical isolation, MOV or silicon avalanche devices. Fuses are not permitted for surge protection.

C. Wiring: Provide complete electric wiring for DDC system, including wiring to transformer primaries. Control circuit conductors shall not be run in the same conduit as power wiring over 100 volts. Circuits operating at more than 100 volts shall be in accordance with DIVISION 16 – ELECTRICAL. Circuits operating at 100 volts or less shall be defined as low voltage and shall be run in liquid-tight flexible conduit, galvanized rigid steel conduit (for exposed interior and exterior conduit runs), or electrical metallic tubing (for concealed interior conduit runs) in accordance with DIVISION 16 – ELECTRICAL. Provide circuit and wiring protection as required by NFPA 70. HVAC plenums include the space between a drop ceiling and the architectural ceiling, within walls and within ductwork. Protect exposed wiring from abuse and damage.

1. AC Control Wiring: Control wiring for 24 volt circuits shall be insulated copper 18 AWG minimum and shall be rated for 300 VAC service.
2. Wiring for 120 volt shall be 14 AWG minimum and shall be rated for 600 VAC service.
3. Analog Signal Wiring: Analog signal wiring shall be 18 AWG single or multiple twisted pair. Each cable shall be 100 percent shielded and have 20 AWG drain wire. Each wire shall have insulation rated to 300 VAC. Cables shall have an overall aluminum-polyester or tinned-copper (cable-shield tape), overall 20 AWG tinned copper cable drain wire and overall cable insulation rated to 300 VAC.
4. Install all control wiring in conduit separate from AC power circuits.
5. Provide junction box with conduit seals, similar to that indicated for air handling unit power entry, for all conduits exposed to conditioned air to prevent condensation inside the conduit.

PART 3 EXECUTION

3.1 COOPERATION WITH OTHER TRADES AND CONFLICT IN WORK

A. Contractor shall examine all drawings of proposed work and coordinate his work with other trades. Work conflicts shall be brought to attention of the State and work rearranged or modified in accordance with his decision.

B. If changes in indicated locations or arrangements of work are required, they shall be made by Contractor without additional charge to the State provided that these changes were ordered before work is installed and no extra material or labor are required.

C. Should Contractor determine that extra material and labor will be required to accommodate any rearrangement, he shall first submit detailed estimate of cost for required changes and proceed with work only upon written authority of the State.

3.2 CUTTING AND PATCHING

A. Cut all holes necessary for installation of work under this Section.

B. Patching of all holes, etc., will be done under other sections of specification. Patch any holes cut unnecessarily.

3.3 EQUIPMENT IDENTIFICATION

A. Label DDC panels and other equipment as specified in Section 230300 GENERAL MECHANICAL REQUIREMENTS.

3.4 ACCESS TO EQUIPMENT

A. Install all control devices, specialties, valves and related items to provide easy access for operation, inspection, repair and maintenance. If these items are concealed behind walls or ceilings of non-removable type construction, provide access panels of proper size for easy access at no additional cost to the State.

3.5 IDENTIFICATION OF VALVES

A. As specified in Section 230300 GENERAL MECHANICAL REQUIREMENTS.

3.6 DDC SYSYEM INSTALLATION

A. Perform installation under supervision of competent technicians regularly employed in the installation of DDC systems. Provide components for a complete and operational system.

B. Wiring Criteria:
1. Input/Output identification: Permanently label each field wire, cable, or pneumatic tube at each end with unique identification.
2. Rigid or flexible conduit shall be terminated at all sensors and output devices.
3. Surge Protection: Install surge protection in accordance with the manufacturer's recommendations.
4. Grounding: Ground controllers and cabinets to a good earth ground. Ground controller to a ground in accordance with DIVISION 16 - ELECTRICAL. Grounding of the green ac ground wire, at the breaker panel, alone is not adequate. Run metal conduit from controller panels to adequate building grounds. Ground sensor drain wire shields at controller end.
5. Contractor is responsible for correcting all associated ground loop problems.

C. Digital Controllers:
1. Do not divide control of a single mechanical system such as an air handling unit, boiler, chiller, or terminal equipment between two or more controllers. A single controller shall manage control functions for a single mechanical system. It is permissible, however, to manage more than one mechanical system with a single controller.
2. Provide digital control cabinets that protect digital controller electronics from dust, at locations shown on the drawings.
3. Provide a main power switch at each highest level LAN digital controller within controller cabinet.
4. No multiplexing of points is allowed.

D. Temperature Sensors: Provide temperature sensors in locations to sense the appropriate condition. Provide sensor where they are easy to access and service without special tools.

Calibrate sensors to accuracy specified. In no case will sensors designed for one application be installed for another application.

1. Duct Temperature Sensors:
   a. Provide sensors in ductwork in general locations as indicated. Select specific sensor location within duct to accurately sense appropriate air temperatures. Do not locate sensors in dead air spaces or positions obstructed by ducts or equipment. Install gaskets between the sensor housing and duct wall. Seal duct and insulation penetrations.
   b. String duct averaging sensors between two rigid supports in a serpentine position to sense average conditions. Thermally isolate temperature sensing elements from supports. Provide duct access doors to averaging sensors.
2. Immersion Temperature Sensors: Provide thermowells for sensors measuring temperature in liquid applications or pressure vessels. Locate wells to sense continuous flow conditions. Do not install wells using extension couplings. Where piping diameters are smaller than the length of the wells, provide wells in piping at elbows to effect proper flow across entire area of well. Wells shall not restrict flow area to less than 70 percent of pipe area. Increase piping size as required to avoid restriction. Provide thermowells with thermal transmission material within the well to speed the response of temperature measurement. Provide wells with sealing nuts to contain the thermal transmission material.
3. Outside Air Temperature Sensors: Provide outside air temperature sensors on north side of the building, away from exhaust hoods, air intakes and other areas that may affect temperature readings. Provide sunshields to protect outside air sensor from direct sunlight.

E. Damper Actuators: Actuators shall not be mounted in the air stream.

F. Thermometers: Provide thermometers at locations indicated. Mount thermometers to allow readability when standing on the floor.

G. Pressure Sensors:
   1. Differential Pressure:
      a. General: Install pressure sensing tips in locations to sense appropriate pressure conditions.
      b. Duct Static Pressure Sensing: Locate duct static pressure tip approximately two-thirds of distance from supply fan to end of duct with the greatest pressure drop.
      c. Pumping Proof with Differential Pressure Switches: Install high pressure side between pump discharge and check valve.

H. Control Drawings: Post laminated copies of as-built control system drawings in each mechanical room. Provide six (6) sets of as-built drawings to the activity.

3.7 ADJUSTMENTS

A. Calibrate instrumentation and controls and verify the specified accuracy using test equipment with a test equipment accuracy. Adjust controls and equipment to maintain conditions indicated, to perform functions indicated, and to operate in the sequence specified.

3.8 FIELD QUALITY CONTROL

A. General:
   1. Demonstrate compliance of the heating, ventilation, and air conditioning control system with the contract documents. Furnish personnel, equipment, instrumentation, and supplies necessary to perform calibration and site testing. Ensure that tests are performed by

competent employees of the DDC system installer or the DDC system manufacturer regularly employed in the testing and calibration of DDC systems.

2. Testing will include the field tests and the performance verification tests. Field tests shall demonstrate proper calibration of input and output devices, and the operation of specific equipment. Performance verification test shall ensure proper execution of the sequence of operation and proper tuning of control loops.
3. Obtain approval of the plan for each phase of testing before beginning that phase of testing. Give to the Contracting Officer written notification of planned testing at least 45 days prior to test. Notification shall be accompanied by the proposed test procedures. In no case will the Contractor be allowed to start testing without written State approval of test procedures. The test procedures shall consist of detailed instructions for complete testing to prove performance of the heating, ventilating and air conditioning system and digital control system.
4. Before scheduling the performance verification test, furnish the field test documentation and written certification to the Contracting Officer that the installed system has been calibrated, tested, and is ready for the performance verification test. Do not start the performance verification test prior to receiving written permission from the Government.

3.9 TRAINING

A. Provide training in accordance with Section 230300 GENERAL MECHANICAL REQUIREMENTS. The controls contractor shall provide the following training services:

1. Sixteen (16) hours of on-site orientation by a field engineer who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the control system software layout and naming conventions, and a walk through of the facility to identify panel and device locations.
2. General: Provide training course schedule, syllabus, and training materials 45 days prior to the start of training. Conduct training courses for designated personnel in the maintenance and operation of the HVAC and DDC system. Orient training to the specific system being installed under this contract. Use operation and maintenance manual as the primary instructional aid. Operational and maintenance manuals shall be provided for each trainee with four additional sets, two sets delivered for archiving at the project site, one set for the mechanical contractor, and one set for the design engineer. Training manuals shall include an agenda, defined objectives and a detailed description of the subject matter for each lesson. Furnish audio-visual equipment and all other training materials and supplies. A training day is defined as 8 hours of classroom or lab instruction, including two 15 minute breaks and excluding lunch time, Monday thru Friday, during the daytime shift in effect at the training facility. For guidance, assume the attendees will have a high school education and are familiar with HVAC systems. The minimum amount of training for this project shall be 24 hours.
3. Operator Training: Operator training shall include the detailed review of the control installation drawings, points list, and equipment list. The instructor shall then walk through the building identifying the location of the control devices installed. For each type of systems, the instructor shall demonstrate how the system accomplishes the sequence of operation.
4. From the workstation, the operator shall demonstrate the software features of the system. As a minimum, the operator demonstrate and explain logging on, setting passwords, setting up a schedule, trend, point history, alarm, and archiving the database.
5. Maintenance Training: The system maintenance course shall be taught at the project site within one month after the completion of the operators training. The course shall last for one 8 hour training day. The course shall include answering questions from the last training session, trouble shooting and diagnostics, repair, instructions, preventive maintenance procedures and schedules, and calibration procedures.

3.10 SEQUENCE OF OPERATION

A. Sequence of operations shall be as indicated.

3.11 LAPTOP

A. Laptop shall be provided upon project completion.

3.12 SYSTEMS INTEGRATION/DDC SPECIFIC REQUIREMENTS

A. DDC Remote Access: The Direct Digital Control (DDC) system provided shall include the capability for multiple users to access the DDC simultaneously from remote locations. Interface shall be to the entire DDC and provide the capability to monitor all I/O and adjust parameters.

B. Open Systems Integrator:
   1. VFD Integrator Interface:
      a. The BAS system shall include appropriate hardware equipment and software to allow two way data communications between the BAS system and the VFD manufacturer's control panel.
      b. It shall be the responsibility of the BAS Contractor to coordinate with the VFD manufacturer to provide a functional data communications connection.
      c. All data supported by the VFD communication protocol shall be mapped into the supervisory DDC controller's database and shall be displayed on data screens at the Operator Workstation and shall be transparent to the Operator Workstation and shall be transparent to the operator.
      d. The BAS Contractor shall furnish either the OSP or BACnet communications interface as required by the VFD manufacturer.
      e. The BAS Contractor shall provide all communications and power wiring and gateway panel installation for the DDC system. The VFD manufacturer shall provide all hardware for connection of the manufacturer's processor.
      f. The BAS Contractor shall provide all hardware and software required for the VFD manufacturer's gateway interface.

   2. Chiller Integrator Interface:
      a. The BAS system shall include appropriate hardware equipment and software to allow two way data communications between the BAS system and the chiller manufacturer's chiller control panel.
      b. It shall be the responsibility of the BAS Contractor to coordinate with the chiller manufacturer to provide a functional data communications connection.
      c. All data supported by the chiller communication protocol shall be mapped into the supervisory DDC controller's database and shall be displayed on a chiller data screen at the Operator Workstation and shall be transparent to the operator.
      d. The BAS Contractor shall furnish either the OSP or BACnet communications interface as required by the chiller manufacturer.
      e. The BAS Contractor shall provide all communications and power wiring and gateway panel installation for the DDC system. The chiller manufacturer shall provide all hardware for connection of the manufacturer's processor.
      f. The BAS Contractor shall provide all hardware and software required for the chiller manufacturer's gateway interface.

3.13 PRE-ACCEPTANCE CERTIFICATION

A. The Contractor shall provide written certification that the entire DDC system has been functionally tested prior to scheduling the acceptance test. The pre-acceptance test shall be performed in conjunction with the Test and Balance work to ensure proper water flows.

B. Deficiencies discovered during the pre-acceptance test shall be corrected and retested.

C. The pre-acceptance test does not take the place of the manufacturer's recommended checkout or startup procedures or report.

D. Requirements in related sections are independent from the requirements of this section and shall not be used to satisfy any of the requirements specified in this section.

E. Eight (8) copies of the complete certification and test report shall be submitted to the State at least 2 weeks prior to scheduling of the acceptance test.

F. Test Data: The Contractor shall provide the State with typewritten schedules of readings taken during the pre-acceptance test indicating the required or specified readings, the first reading taken and final reading for the following items:

1. Motorized Valves:
   a. Valve Stroke Full Open/Close
   b. Feedback Signal to ATCS Correspond to Actual Condition
   c. Position Commanded by ATCS Correspond to Actual Position
2. Temperature Sensors:
   a. Has Sensor Been Calibrated?
   b. ATCS Reading
   c. Adjacent Thermometer Reading
3. Variable Frequency Drives:
   a. Contactor Bypass Operational
   b. Drive Shuts Pump Down in "Off" Position
   c. Drive Starts Pump in "Manual" Position
   d. Drive Operates from ATCS in "Auto" Position
4. ATC System:
   a. Record all point conditions (new and existing)
   b. Verify Proper Switching from Normal to Emergency Power Mode
   c. Simulate Failure of all Equipment
6. Chillers:
   a. Chilled water temperatures
   b. Chilled water pressures
   c. Condenser water temperatures
   d. Condenser water pressures

5. Cooling Towers:
   a. Condenser water temperatures

6. Pumps:
   a. Suction and discharge pressures
   b. Motor full load amps

9. Heat Pumps:
   a. Cold side water temperatures
   b. Cold side water pressures

c. Hot side water temperatures
d. Hot side water pressures

3.14 ACCEPTANCE PROCEDURE

A. Upon completion of the calibration, Contractor shall startup the system and perform all necessary testing and run diagnostic tests to ensure proper operation. Contractor shall be responsible for generating all software and entering all databases necessary to perform the sequence of control and specified software routine. An acceptance test in the presence of the State Representative(s) shall be performed.

B. Alarms: Alarms shall be controlled as follows:
1. Flexible time delays shall be used before generating an alarm to insure it is a true alarm.
2. Alarms shall be capable of being printed out on a local terminal.
3. All alarm messages shall have a time and date.
4. Alarm messages shall be capable of being sent to remote locations via auto dial modem.
5. The network shall be capable of sending messages to different telephone numbers based on type of alarm, time of day, or if the previous dialed number did not answer.

C. Control: The control strategies specified in the Sequence of Operation shall be implemented and operational per user-defined point parameters. Further, software controls which enable the Sequence of Operation shall be relatively simple to adjust and modify, should the user wish to adjust such parameters.

D. Reports:
1. All reports shall be capable of the following:
   a. Custom user design
   b. User defined units and labels
   c. Being generated on a periodic basis or on a requested basis
   d. Being generated and printed on a local or remote terminal
2. Status Reports: Status reports shall contain current status of all controlled equipment and current value of all sensors.
3. Runtime Reports: Runtime reports shall contain the runtime of controlled equipment.
4. Summary Reports: Summary reports shall be capable of containing any of the following information if requested by the State.
   a. High and low temperatures
   b. Current and past electrical peak demands
   c. Past energy consumption and cost

3.15 ONE YEAR MAINTENANCE SERVICE CONTRACT

A. Provide maintenance service for all laboratory service piping system components as specified in and in accordance with the requirements and schedule of Section 230300 GENERAL MECHANICAL REQUIREMENTS.

3.16 OPERATION AND MAINTENANCE MANUAL

A. Shall be provided as specified in Section 230300 GENERAL MECHANICAL REQUIREMENTS. The instructions shall include, but not be limited to, the following:
1. Wiring and control diagrams and input/out point identification list with data to explain the detailed operation and control of each component.
2. A control sequence describing startup, operation, shutdown and emergency conditions.
3. Field information including location, device type and function and electrical parameters.
4. Complete hardcopy of all program listings and functions.

5. Instructions on programming and testing. This shall include all control programs, variables, set points, time periods, messages, passwords, and other information necessary to load, alter, test and execute the system.
6. Complete description of programming language, including commands; editing and writing control programs, printouts and logs; and mathematical calculations.
7. Instructions on modifying any control point, verifying error status, changing passwords, and initiating/disabling control programs and alarms.
8. Two (2) floppy diskettes with backup program for each control unit.
9. Operating and maintenance instructions for each piece of equipment.
10. Manufacturer's bulletins, cuts and descriptive data.
11. Parts lists and recommended spare parts.
12. Name and phone number to call for service during normal working hours and in case of emergency nights and weekends.

END OF SECTION

SECTION 232113 – CHILLED WATER PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Scope of Work: Central Plant Modifications

B. This section covers the furnishing, fabrication, delivery and installation of the chilled water and other miscellaneous mechanical piping systems complete, including but not limited to the following:
   1. Valves and accessories.
   2. Piping and fittings.
   3. Manufacturer's literature, shop drawings and record drawings.
   4. Testing and guarantee.

1.2 RELATED WORK SPECIFIED IN OTHER SECTIONS

A. Mechanical work as specified in Section 230300 GENERAL MECHANICAL REQUIREMENTS unless specified otherwise in other sections of Division 23 HEATING, VENTILATING, AND AIR CONDITIONING.

B. Vibration isolation work specified in Section 220548 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL.

C. Mechanical insulation work specified in Section 230700 HVAC INSULATION.

D. Central Refrigeration Equipment specified in SECTION 236410 CENTRAL REFRIGERATION EQUIPMENT.

E. Testing and balancing is specified in Section 230593 TESTING, ADJUSTING, AND BALANCING FOR HVAC.

F. Control valves and control end devices specified in Section 230923 DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

1.3 SUBMITTALS

A. Submit in accordance with Section 013300 SUBMITTAL PROCEDURES and Section 230300 GENERAL MECHANICAL REQUIREMENTS.

B. Shop Drawings: Submit shop drawings of plans, performance data and details showing locations and installation including but not limited to the following (note: shop drawing of these items can be combined with the shop drawing for the air conditioning equipment shop drawings):
   1. Chilled water piping interior locations.

C. Product Data: Submit product data for the following:
   1. Pipes and valves

D. Schedules:
   1. Schedule of equipment listing name and addresses of manufacturers; manufacturer's local supplier's name, address and phone number; catalog numbers and trade names in accordance with paragraph 1.05.B of Section 230300 GENERAL MECHANICAL REQUIREMENTS.

2. Maintenance service contract and schedule

E. Reports: None

F. Certificates of Conformance or Compliance:
1. Submit certificates of conformance for performance and characteristics specified, the listed standards and in accordance with Section 230300 GENERAL MECHANICAL REQUIREMENTS for the following:
   a. Pipes and valves
2. Submit certificates of qualifications for manufacturer's representatives: None

G. As-Built Drawings: Submit drawings in accordance with Section 230300 GENERAL MECHANICAL REQUIREMENTS.

H. Guarantee and Certificate: Submit one year guarantee and certificate in accordance with Section 230300 GENERAL MECHANICAL REQUIREMENTS.

PART 2 PRODUCTS

2.1 PIPING AND FITTINGS

A. General: All pipe and pipe fittings shall be suitable for 125 psi minimum working pressure, in accordance with the latest edition of ASTM and ANSI specifications as indicated.

B. Service: Aboveground chilled water.

ITEM	SIZE	DESCRIPTION
Pipe	4-inch and smaller	Hard drawn copper tubing, type L, conforming to ASTM B88.
	5-inch and larger	Standard weight, black steel, ASTM A53, beveled ends. Alternate system: Victaulic type fittings and couplings.
Fittings	4-inch and smaller	Wrot copper soldered joint type conforming to ANSI B16.18 and soldered joints with 95-5 tin antimony alloy or brazed.
	5-inch and larger	Black steel, standard weight, buttweld type, ASTM A234, ANSI B16.9. Use standard weight weld rings at joints of piping if required by approved welding procedure. Alternate system: Victaulic type fittings and couplings.
Unions	2-1/2-inch and smaller	For copper tubing shall be cast bronze with soldered ends.
Flanges	4-inch	Cast bronze, 150-lb. soldered joint type flanges, ANSI B16.24.
	5-inch and larger	Forged steel, 150-lb. weld neck, flat-faced or raised face to match flange on valves or equipment, ASTM A181, ANSI B16.5. Alternative system: 150-lb. Victaulic flanges.

C. Makeup, condenser water drain and overflow lines: Shall be hard drawn copper tubing, Type L, ASTM B88 with cast bronze soldered joint ANSI B16.18 fittings or wrot copper pressure fittings, 95-5 tin antimony solder.

D. Chemical treatment: Schedule 80 CPVC pipe with solvent joint fittings.

2.2 VALVES

A. Victaulic type connections shall be an approved connection type if used in conjunction with Victaulic type piping system. Requirements of valve are the same; only the end connection type will change to grooved type.

B. Provide extended neck for valves requiring insulation.

ITEM	SIZE	DESCRIPTION
Check Valves	1-1/2-inch and smaller	125-lb. S.W.P., bronze body, swing check valve, bronze disc, bronze hinge pin, Buna-N resilient seat, threaded ends. Provide NIBCO T-413 or approved equal.
	2-inch and larger	125-lb. S.W.P., double door check valve, steel or cast iron body, aluminum bronze doors, stainless steel spring and pins, Buna-N resilient seat, non-slam closure, lug body style. Provide APCO Series 9000L or approved equal.
Ball Valves	2-inch and smaller	125-lb. S.W.P., bronze body, Type 316 stainless steel ball and stem, PTFE seat, full port, lever handle with integral stop, threaded ends. Provide NIBCO T-580-66 or approved equal.
Plug Valves	2-1/2-inch and smaller	150-lb. S.W.P, bronze body, eccentric resilient chloroprene faced plug, lever handle with integral stop, threaded ends. Provide Dezurik Fig. 120, Val-matic or approved equal
	3-inch and larger	125-lb. S.W.P., cast iron body, resilient chloroprene faced eccentric plug, flanged ends and manual operator with handwheel actuator and right angle gear drive. Provide DeZurik Fig. 118, Val-matic or approved equal.
Butterfly Valves	2-inch and larger	MSS-SP67, Type I tight shutoff valve, ductile iron lug body, stainless steel stem, aluminum bronze disc, EPDM seal, positive latching lever actuator with memory stop. For sizes 4-inch and larger, provide worm gear drive with handwheel. For valves located more than 5 feet above finished floor, provide chain wheel operator and chain. Provide NIBCO LD-2000, Bray or approved equal.
Motorized Butterfly Valves	2-inch and larger	Butterfly valve as specified. Provide electric actuator as indicated.
Motorized Ball Valves	2-inch and larger	Ball valve as specified. Provide electric actuator as indicated.

2.3 ELECTRIC ACTUATOR

A. Two position actuators shall be electric type with spring return so that, in the event of power failure, actuators shall fail safe in the normally closed position as specified. Modulating actuators shall be compatible with the DDC control system. Actuators shall be quiet operating and function properly within the range of 85 to 110 percent of the motive power.
   1. Electric Actuators: Provide direct drive electric actuators for all valve applications. When operated at rated voltage, each operator shall be capable of delivering the torque required for continuous uniform movement of the valve and shall have end switch to limit travel or shall withstand continuous stalling without damage. Operators shall function properly with range of 85 to 110 percent of line voltage. Provide gears of steel or copper alloy. Fiber or reinforced nylon gears may be used for torques less than 16 inch pounds. Provide hardened steel running shafts in sleeve bearing of copper alloy, hardened steel, nylon, or ball bearing. Provide two-position operators of the single direction, spring return, or reversing type. Equip valve operators with a force limiting device such as spring yield so that, when in a relaxed position, device shall maintain a pressure on valve disc equivalent to system pressure at valve. Provide reversible shaded pole, split capacitor, synchronous, or stepped type electric motors. Provide NEMA 4 actuator housing.
   2. Control Relays: Shall be double pole, double throw (DPDT), UL listed, with contacts rated to the application, and enclosed in a dustproof enclosure. Equip with a light indicator which is lit when coil is energized and is off when coil is not energized. Relays shall be socket type, plug into a fixed base, and be replaceable without need of tools or removing wiring.
   3. End Switch: Provide each actuator with end position switches to indicate closed and open positions. Switches shall be double pole, double throw (DPDT), UL listed, with contacts rated to the application, and enclosed in a dustproof enclosure. Equip with a light indicator which is lit when coil is energized and is off when coil is not energized.

2.4 PIPE HANGERS AND SUPPORT

A. Hangers and supports shall be of manufacturer and type specified or as indicated or approved equal. Pipe supports and hangers in contact with copper piping shall be copper or plastic coated. Provide hot-dipped galvanized pip hangers and supports.

B. Shields: Provide protection shields at hanger points of insulated piping. Shields shall be Crawford Fig. 25, Elcen Fig. 219, or Fee and Mason Fig. 81 or Grinnell Fig. 167.

C. Supports:
   1. Piping shall be supported from structural steel, grouted CMU walls, or concrete slab only; piping shall not be supported in any manner from the roofing.
   2. Drilled-In Threaded Inserts: Where supports in slabs are required after concrete has been poured, Phillips "Redhead" drilled in threaded inserts shall be provided, installed in accordance with manufacturer's recommendations.
   3. Expansion Anchors and Power-Actuated Fasteners and Devices: Install lead shield anchors or power actuated sleeves, fasteners and devices in accordance with manufacturer's recommendations. Powder actuated pins are not allowed to be "shot" into the concrete structure.

D. Schedules: Pipe support spacing and sizes of pipe hanging suspension rods shall conform to the following table, except support spacing for copper tubing shall not exceed 6 feet on centers:

PIPE SIZE	SUPPORT SPACING
1/2-inch & 3/4-inch	Not over 6-ft.-6-inch
1-inch & 1-1/4-inch	Not over 8-ft.-6-inch
1-1/2-inch	Not over 10-ft.-0-inch
2-inch & 2-1/2-inch	Not over 12-ft.-0-inch
3-inch	Not over 12-ft.-0-inch
4-inch	Not over 14-ft.-0-inch
6-inch	Not over 17-ft.-0-inch
8-inch to 12-inch	Not over 21-ft.-0-inch
14-inch to 18-inch	Not over 25-ft.-0-inch

PIPE SIZE	ROD SIZE
Up to 2-inch	3/8-inch
2-1/2-inch	1/2-inch
4-inch to 5-inch	5/8-inch
6-inch	3/4-inch
8-inch to 12-inch	7/8-inch
14-inch to 18-inch	1-inch

E. Supplementary Steel: Provide all necessary supplementary steel for proper support or attachment of hangers. Steel shall be painted with one coat of rust inhibiting primer.

F. Single Hangers: Unless otherwise indicated, support single pipe runs as follows:
1. Pipe 2-1/2 inch and smaller: Split ring type hanger, Grinnell Fig. 104, Crawford Fig. 104, Fee and Mason Fig. 199, Elcen Fig. 92 or adjustable clevis hanger.
2. Pipe 3 inch and larger: Clevis hanger conforming to MSS SP-69, Type 1.

G. Riser Clamps: Carbon steel conforming to MSS SP-69 Type 8. Grinnell Fig. 261, Fee and Mason Fig. 241.

2.5 STRAINERS

A. Wye Strainer: Provide wye ("Y") type strainer at suction side of pump, ahead of all flow control valves and as indicated, bronze body (2-inch and smaller) or cast iron body (2-1/2-inch and larger) with stainless steel strainer screens with not larger than 0.033-inch perforations and threaded ends (2-inch and smaller) or flanged ends (2-1/2-inch and larger). Provide valved flushing line from bottom of each strainer. Provide Hayward Model 80, Mueller or approved equal.

B. Basket Strainer: Provide basket type strainer at suction side of pump and as indicated, simplex style, ductile iron body with stainless steel strainer basket with not larger than 1/32-inch perforations, quick opening cover and 150 lb. flanged ends. Provide valved flushing line from bottom of each strainer. Provide Hayward Model 72, Mueller or approved equal.

C. Suction diffuser: Angle pattern flow straightening fitting equipped with a combination diffuser-strainer, flow straightening vanes, stainless steel diffuser- strainer with 3/16 inch diameter perforations, permanent magnet and adjustable support foot. Fitting shall be of cast iron construction, flanged ends or ductile iron with grooved ends and with free area equal to five times the cross sectional area of the pump suction and designed to be mounted to the pump suction connection. Bell & Gossett, Taco or approved equal.

2.6 THERMOMETERS

A. Blue spirit filled lens tube type with separable socket. Adjustable, 9-inch scale, 0 degree F to 100 degree F range for chilled water application and 0 degrees F to 160 degrees F for condenser water application with 2 degree F maximum scale divisions, enameled die-cast aluminum adjustable angle case. Provide stainless steel wells for steel pipes and brass wells for copper pipe and of suitable length to accommodate pipe size and thickness of insulation.

2.7 PRESSURE GAUGES

A. Pressure gauges shall be Grade A, accurate within 1 percent of full scale, phosphor bronze Bourdon tube, spring type, with 4-1/2-inch diameter dials unless otherwise indicated, with recalibrating screws. Socket shall be 1/4 inch NPT forged brass, bottom outlet. Gauges shall have plain cast aluminum cases with screwed rings finished in black enamel or chromed and shall be installed with necessary piping, including heavy duty needle valve.

B. Pressure gauges ranges shall be such that the position of the pointer during normal operation will be 50 percent of dial range.

2.8 CHILLED WATER AUTOMATIC FLOW CONTROL DEVICES

A. Automatic Flow Control Valves: Provided individually selected and factory calibrated by the flow control valve manufacturer for the service specified. The valves shall automatically limit the rate of flow of the system to the required design capacity regardless of system fluctuations. Valves shall regulate flow within 5 percent of their tag rating over an operating pressure differential of at least 14 times the minimum required for control. Provide tamper-proof valves with body tappings suitable for connecting instruments for verifying flow control performance. Provide the self-cleaning, cartridge-piston type with stainless steel or Monel, variable area orifices. Valves shall be copper or bronze body and designed for a minimum service pressure of 125 psig. Valve bodies shall have threaded or flanged connections. Furnish each automatic flow control valve with a valve kit located outside of insulation, and hose fittings suitable for use with the measuring instruments as specified. Provide a metal identification tag fastened to each of the flow control valves with a chain. The tag shall include manufacturer's name, model number, rated flowrate in gallons per minute, and operating pressure differential range. Provide a portable meter with a direct reading gauge, hoses, shutoff valves, vent valves, “psi” to “gpm” conversion chart, and carrying case that is compatible with the flow control valves provided. Portable flow meter shall be turned over to the State at the end of the project. Provide Griswold Controls, copper sweat type, threaded or flange type with dual hose meter KVT #3429A, Flow Design Inc. or approved equal.

2.9 AIR VENT VALVE

A. High capacity float type, 150 psi, 3/4" NPT, Taco 418, Bell & Gossett or approved equal.

2.10 FLOW SENSOR AND TRANSMITTER

A. Provide a turbine flow meter complete with all installation hardware necessary to enable insertion and removal of the meter without system shutdown. The flow meter shall have two contra-rotating axial turbines, with electronic impedance-based sensing and an averaging circuit to reduce measurement errors due to swirl and flow profile distortion. Wetted metal components shall be 316L SS. The maximum operating temperature shall be 280 degrees F. Each flow meter shall be individually wet-calibrated against a primary volumetric standard that is accurate to within 0.1% and traceable to NIST. The manufacturer’s certificate of

calibration shall be provided with each flow meter. Accuracy shall be within ± 0.5% of rate at the calibrated velocity, within ± 1% of rate over a 10:1 turndown (3.0 to 30 ft/s) and within ± 2% of rate over a 50:1 turndown (from 0.4 to 20 ft/s). The flow meter shall include integral analog output(s), 4-20 mA, 0-10V, or 0-5V. Provide Onicon F-1210 or approved equal.

PART 3 EXECUTION

3.1 COOPERATION WITH OTHER TRADES AND CONFLICT IN WORK

A. Contractor shall examine all drawings of proposed work and coordinate his work with other trades. Work conflicts shall be brought to attention of the State and work rearranged or modified in accordance with his decision.

B. If changes in indicated locations or arrangements of work are required, they shall be made by Contractor without additional charge to the State provided that these changes were ordered before work is installed and no extra material or labor are required.

C. Should Contractor determine that extra material and labor will be required to accommodate any rearrangement, he shall first submit detailed estimate of cost for required changes and proceed with work only upon written authority of the State.

3.2 CUTTING AND PATCHING

A. Cut all holes necessary for installation of work under this Section.

B. Patching of all holes, etc., will be done under other sections of specification. Patch any holes cut unnecessarily.

3.3 ACCESS TO EQUIPMENT

A. Install all control devices, specialties, etc., to provide for easy access for operation, repair and maintenance.

B. If concealed, access doors and panels shall be provided. Coordinate installation of items where access doors and panels are required for proper access. Access is required where valves or controls are installed behind walls or above non-removable ceilings.

3.4 WORKMANSHIP AND FABRICATION

A. Pipe Installation:
1. Pipe shall be cut accurately to measurements established at the job site and worked into place without springing or forcing, properly clearing all windows, doors and other openings. Cutting or weakening of the building structure to facilitate piping installation will not be permitted.
2. Pipes shall be cut square, shall have burrs removed by reaming, and shall be so installed as to permit free expansion and contraction without damage to joints or hangers. Install special swing and expansion joints in pipe lines where required to accommodate specified movement. Filings, dust, or dirt shall be wiped from interior of the pipe before connections are made.
3. Changes in direction shall be made with fittings. All piping shall be installed with sufficient pitch to insure adequate drainage.
4. Screw joints shall be made with tapered threads properly cut conforming to requirements of NBS handbook H28. Joints shall be made perfectly tight with a stiff mixture of

litharge and glycerin or other approved threaded joint compound applied with a brush to the male threads only. Not more than three threads shall show after the joint is made up.

5. Welded joints shall conform as to workmanship, testing, qualification of welders and general requirements, with welding section of ANSI B31.9. The State reserves the right to require qualifying demonstration of any welder assigned to job by Contractor at no additional cost.
6. Flanges shall be suitable for the required operating pressures and temperature conditions. Gaskets shall be fiber plastic or synthetic material suitable for water service. All nuts, bolts and washers used shall be galvanized for ferrous flanges and brass for copper or bronze flanges.
7. Pipes passing through walls or concrete floors shall be provided with pipe sleeves fitted into place at time of construction. Sleeves shall not be installed in structural members. Each sleeve shall extend through its respective wall or floor and shall be cut flush with each surface. Unless otherwise indicated, sleeves shall be of such size as to provide a minimum of 1/4 inch all around clearance between jacket over insulation and sleeves. Space between sleeve and piping shall be packed with twisted jute packing and then sealed with waterproof sealant. Where pipes pass through fire rated walls or floors, seal both ends of sleeve with Underwriter's Laboratories listed thermal barrier material to maintain fire rating.
8. All piping systems shall be thoroughly tested for leaks prior to burying.

3.5 PIPE HANGERS AND SUPPORT

A. Provide adjustable hangers, clamps, supplementary steel, etc., as required for proper support of all pipe lines. Hangers shall be of adequate size to permit covering to run continuously through hangers. Coordinate location of hangers with light fixtures as shown on Electrical drawings. Hangers provided under other sections shall not be used for support of piping or equipment provided under this section unless permission is granted in writing.

B. Supports shall secure pipes, conduits in place, shall prevent pipe vibration, maintain required grading by proper adjustment, provide for expansion and contraction, and shall make neat appearance.

C. Design supports of strength and rigidity to suit loading, service, and in manner which will not stress unduly the building construction.

D. Where support is from concrete construction, take care not to weaken concrete or penetrate waterproofing.

E. Vertical risers shall be secure at each floor level and additional supported at bottom of riser to prevent slipping or falling of piping.

3.6 VIBRATION ISOLATION

A. Vibration isolation shall be provided as specified in Section 220548 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL.

B. All pipe connections to reciprocating and or rotating equipment shall be made with flexible pipe connections.

3.7 THERMOMETERS

A. Install thermometers and wells where indicated and at air handling units supply and return chilled water piping.

3.8 PRESSURE GAUGES

A. Install pressure gauges where indicated and at supply and return chilled water connection at each cooling coil.

3.9 STRAINER

A. Install strainer upstream of control valves, and as indicated on contract drawings.

B. Contractor shall clean all strainers not more than one week before final inspection.

3.10 DIELECTRIC CONNECTIONS

A. Copper pipe shall be insulated from direct contact with ferrous piping connections by approved insulating (dielectric) unions or couplings or flanges.

3.11 FLOW SENSOR

A. Install flow sensor with manufacturer's recommended straight pipe upstream and downstream of sensor.

3.12 PAINTING

A. All ferrous metal shall be given one shop coat of red lead or other approved rust resisting paint. Where zinc coated metal is furnished, it shall not be shop primed unless specifically called for, but all abraded places and welds shall be touched up with Galvalloy or approved equal.

B. Pipe hangers, supports and other iron work in concealed spaces shall be thoroughly cleaned and painted with one coat of asphalt varnish. Finish painting of exposed items is specified in Section 099000 PAINTING.

3.13 IDENTIFICATION OF PIPING

A. As specified in Section 230300 GENERAL MECHANICAL REQUIREMENTS.

3.14 IDENTIFICATION OF VALVES

A. As specified in Section 230300 GENERAL MECHANICAL REQUIREMENTS.

3.15 CLEANING AND FLUSHING PIPES

A. Pipes shall be cleaned free of scale and thoroughly flushed of all foreign matter. Provide vents and drains connections and nipples as required to allow flushing the pipes thoroughly.

3.16 CLEANING AND ADJUSTING

A. Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Pipes shall be cleaned free of scale and thoroughly flushed of all foreign matter. Temporary bypass shall be provided for all coils and condensers to prevent flushing water from passing through coils. Strainers and valves shall be thoroughly cleaned. Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. All control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Clean all strainer screens 10 days after acceptance of this project. After cleaning,

refill the system with potable water and water treatment chemicals for closed reheat water system.

3.17 FIELD QUALITY CONTROL

A. Perform inspections and tests as specified herein to demonstrate that piping and equipment, as installed, is in compliance with contract requirements. Start up and operate the system. During this time, periodically clean the various strainers until no further accumulation of foreign material occurs. Exercise care so that minimum loss of water occurs when strainers are cleaned. Adjust safety and automatic control instruments to place them in proper operation and sequence.

1. Hydrostatic Test of Piping System: Test piping system hydrostatically at 125% of the working pressure using water not exceeding 100 degrees F. Conduct tests in accordance with the requirements of ASME B31.9 and as follows. Test piping system after all lines have been cleaned and before applying insulation covering. Remove or valve off from the system, gages, and other apparatus which may be damaged by the test before the tests are made. Install calibrated test pressure gage in the system to observe any loss in pressure. Maintain test pressure for a sufficient length of time to enable an inspection of each joint and connection. Perform tests after installation and prior to acceptance. Notify the State in writing 7 days prior to the time scheduled for the tests.

2. Auxiliary Equipment and Accessory Tests: Observe and check pumps, accessories, and equipment during operational and capacity tests for leakage, malfunctions, defects, noncompliance with referenced standards, or overloading.

3. Backflow Preventers: Backflow preventers shall be tested by locally approved and certified backflow assembly testers. A copy of the test report shall be provided to the State prior to placing the domestic water system into operation, or no later than 5 days after the test.

3.18 TESTING

A. Prior to backfilling, hydrostatically test the piping system to a pressure of 1.5 times the working pressure in accordance with ASME 31.9 Building Services Piping except as modified herein. Hold test pressure for 1 hour. Repair all leaks and retest until satisfactory test is completed.

B. Notify the State 14 days before flushing and testing to allow scheduling to observe the flushing and testing activities.

C. After satisfactory completion of testing, all openings to the piping shall be protected from entrance of foreign objects, dirt, etc. and accelerated corrosion of the interior of the piping.

3.19 FIELD INSTRUCTIONS

A. Provide field instructions as specified in Section 230300 GENERAL MECHANICAL REQUIREMENTS. Upon completion of the work and at a time designated, the services of one or more qualified personnel shall be provided by the Contractor for a period of not less than four (4) hours to instruct the representatives of the State in the operation and maintenance of the items in this section. These field instructions shall cover all the items contained in the bound instructions. Daily sessions shall be separated into small sessions as indicated in Section 230300 GENERAL MECHANICAL REQUIREMENTS.

3.20 TESTING AND BALANCING WATER DISTRIBUTION SYSTEMS

A. Provide testing and balancing as specified in Section 230593 TESTING, ADJUSTING, AND BALANCING FOR HVAC.

END OF SECTION

SECTION 232500 – CHEMICAL TREATMENT

PART 1 - GENERAL

1.1 SUMMARY

Provide chemical water treatment for air conditioning system as indicated, complete with chemicals, testing, labor and equipment to maintain and monitor the systems with treated water for Central Plant Modifications.

1.2 SUBMITTALS

A. Submit in accordance with Section 013300 - SUBMITTALS and Section 230300 - GENERAL MECHANICAL REQUIREMENTS.

B. Submit eight (8) copies of the following to the Project Manager:
   1. Shop drawings and manufacturer's product data showing construction and installation details, equipment, products and chemicals with MSDS.
   2. Manufacturer's installation instructions.
   3. Manufacturer's schematic diagrams.
   4. Manufacturer's operations and maintenance manual.
   5. Manufacturer's guaranty/warranty.
   6. Maintenance Service Contract.
   7. Test Results.

1.3 QUALITY ASSURANCE

A. Water Treatment Contractor (WTC) shall have a minimum of five (5) years water treatment service experience in Hawaii and provides necessary equipment, chemicals and services required to control corrosion, scale, and biological growth in the following systems:
   1. Cooling tower
   2. Condenser water
   3. Chilled water

B. Use qualified personnel with a minimum of five (5) years of field experience or engineering degree in maintaining a water treatment program.

1.4 GUARANTY AND WARRANTY

A. Provide a written guaranty against all defects in materials, workmanship and installation. He shall certify that he will correct any defects other than ordinary wear or improper use that may develop within two years from the date of project acceptance at no cost to the State.

B. The WTC shall warrant the chemicals used in the water treatment program and offered therein will not: endanger the health or safety of persons coming into contact with the materials, damage personal or real property, have a detrimental effect on the metallic or non-metallic materials in the equipment being treated; as long as the WTC instruction are followed.

1.5 PENALTIES FOR NONPERFORMANCE

The Contractor shall not be responsible for repairs/penalties due to flagrant vandalism, fire, storm or related damages that can be attributed to causes beyond his control. However, the contractor shall be responsible for such repairs/penalties if the damages are caused by the Contractor's negligence or failure to properly maintain and repair the equipment/system.

1. The WTC shall clean the system at no cost to the State within thirty (30) days of discovery of the Contractor's failure to meet minimum and service requirements.
2. If the corrosion rate exceeds 2 mils pr year for copper and/or 4 mils per year for steel, the WTC shall be assessed damages of $3,000.00 per chiller in the system.
3. If the bacterial population in the condenser water exceeds 10,000 colonies or is judged to be out of control by the State, the WTC shall take immediate corrective action to reduce the population below 10,000 colonies.
4. The WTC may be assessed $50.00 per incident for each and every calendar day from the date of non compliance. If the WTC fails to correct any condition which does not meet the minimum and service requirements indicated above, the State reserves the right to require the Contractor to replace the WTC and to not allow the WTC to bid or participate in any future State work.
5. If water meter readings indicated excessive water usage by the condenser water system in the absence of mechanical problems in the system, the cost of the excess water used as calculated by the State will be deducted from the WTC billing to the State.
6. Should a chemical cleaning of the chiller tubes become necessary, the WTC shall perform same including the re-brushing of the chiller tubes all at no additional cost to the State, and in addition be assessed $500.00 per chiller per occurrence.
7. Should corrosion damage to any part of the system occur due to the use of oxidizing biocides, halogen levels exceeding 0.5ppm, the WTC shall be required to repair or correct the damages, and in addition be assessed $500.00 per chiller per occurrence or as assessed in paragraph 1.05.A.2 of this section at the State's discretion.
8. Should an unsatisfactory condition be discovered or upon notification, the WTC shall correct it immediately and re-check the system within one week and submit a new report. Failure to re-check and submit new report shall cause the WTC to be assessed $25.00 per incident for each and every calendar day from the date of non-compliance until the re-check and report is submitted.

PART 2 - PRODUCTS

2.1 MATERIALS

A. A minimum of 10% of the estimated annual usage of chemicals specified herein must be delivered to the service sites prior to the start date of this contract. Each package of chemicals delivered shall be labeled with directions for usage per the approved dosage for each chemical. Submit the appropriate MSDS sheets for all chemicals with the initial delivery.

B. The treatment furnished by the WTC shall be one that has been specifically selected and engineered for the water being used in each system of this project.

C. The chemical containers and equipment shall be located within a leak containment system. The WTC shall have an absorbent an/or clean-up system/program that must be available at each site and be submitted and approved by the State prior to start date of this contract.

D. The water treatment shall constantly prevent the build-up of adherent mineral deposits on the heat transfer surfaces of the equipment being treated. Periodic circulation of inhibited descaling acids will not be considered as meeting these specifications.

E. The WTC shall provide any and all testing (e.g.-Legionella, etc.) as may be required to safeguard and protect the State should suspect conditions, allegations or complaints be experienced or as requested at no additional cost to the State.

2.2 CHEMICALS

A. General:
1. All chemicals shall be supplied in their original factory containers and no dilution of chemicals is allowed. Handling of chemicals shall be by the WTC and shall include specific application information, safety, and quality control information, including MSDS sheets.
2. The chemicals provided must meet OSHA, Environmental Protection Agency, and ISO-9000 requirements for safety to personnel and the environment, and must be approved by the State.
3. All chemicals supplied shall have been registered and in satisfactory use in Hawaii for at least two years. Bidder may be required to provide evidence of satisfactory performance of the chemicals offered. The State shall be the sole judge of such satisfaction and the State's decision shall be final.
4. Chemicals, other than those presently being used in the water treatment program, hereinafter referred as "new chemicals", shall be compatible with the existing chemicals, scale and corrosion inhibitor and broad spectrum bacteriostat.
   a. Verification by an independent testing laboratory for the compatibility of the new chemicals shall be submitted upon award and prior to commencement of work.
   b. This verification is required for all chemicals not presently being used in the treatment program.
   c. Should the new chemicals be determined to be incompatible with the chemicals presently in use, the WTC shall be responsible for flushing the system to remove all chemicals before the new chemicals are introduced into the system. Any damages to the system resulting from the failure of the WTC to satisfactorily flush the system shall be repaired by the WTC at his expense and at no cost to the State.

B. Scale and Corrosion Control:
1. Scale and corrosion shall be inhibited by the controlled use of scale and corrosion prevention materials as herein noted.
2. The use of essentially toxic and staining corrosion inhibitors such as chromate will not be permitted. The chilled water systems are closed systems and can use nitrite solutions.
3. Inhibitor such as organic phosphorous type will be permitted.
4. The WTC selected corrosion inhibitors shall have been proven effective by at least two years of usage in the State of Hawaii.
5. Poly-phosphates are not considered effective corrosion inhibitors and shall not be permitted.

C. Biological Growth Control:
1. Bacteria, algae and slime growths shall be prevented in all water circuits by using suitable biocides. Total colonies shall not exceed 10,000.

2. Chemicals may be fed into water circuits requiring continuous make-up by automatic proportional feeding devices or by adding directly to the tower sump as required. Chemicals shall be slug fed into the system on a regular basis and not added continuously.
3. Bromine oxidizing biocides may be used, but shall not include metallic salts, such as tin.
4. A sufficient halogen residual shall be maintained to prevent Legionella. Quaternaries may be used, but only with oxidizing biocides.

2.3 CHEMICAL FEED SYSTEM

A. Provide an automatic chemical feed and monitoring system for the condenser water system.
1. The system shall include a completely automatic proportional pump feed and the bleed-off shall be directly proportional to equipment load indicated by the makeup water.
2. Controls and instrumentation shall include a solid state conductivity meter, controller and a flow through sensor probe.
3. The controller is to be programmed to bleed-off the system and to regulate a preset, adjustable rate solution feed pump.
4. A biocide timer to regulate a preset, adjustable solution feed pump.
5. All components shall be chemical resistant and recommended for use for the chemicals provided.
6. Provide all components as indicated in the Condenser Water Chemical Treatment Schematic Diagram.
7. Plastic piping and fittings shall be PVC, Schedule 80, solvent joint or threaded connections.
8. Metal piping and fittings to connect to the condenser water system shall be the same material and connection type as the main condenser water system.
9. Equipment and interconnecting piping shall be mounted to a wall mounted, backboard, 3/4 inch thick marine plywood, painted to match the adjacent surfaces or approved equal.

B. Provide a closed system valved bypass pot feeder for the chilled water system as a point of insertion of chemicals when required or requested to maintain residual concentration level. Pot feeder shall include drain and fill connections, vertical style with removable fill cover that is rated for the reheat water system design pressure. Provide all isolation valves, throttling valve and drain valves required to allow adjusting flow during operation, draining and isolating the pot feeder when not on-line.

2.4 CORROSION TEST COUPON RACK

A. A certified corrosion test coupon rack kit with test coupons to establish corrosion rates in the condenser water system shall be provided and fully operational when the new air conditioning equipment is started. Test system shall include strainer, isolation and Dole valves, piping kit and test coupons wall mounted on a removable backboard.

B. Prior to installation, the WTC must submit to the State for approval the proposed test system installation plan layout or schematic piping diagram. WTC to perform an ISO 9000 corrosion analysis and test coupons replacement semi-annually at the end of 6 months and 12 months. Make adjustments to the water treatment program as required by findings and submit reports to the State within one (1) month of coupon replacements. Corrosion rates

shall be less than 2 mils per year for copper and 4 mils per year for steel - both with no pitting.

PART 3 - EXECUTION

3.1 INSPECTION

The Contractor and Installer shall examine the areas and conditions under which the water treatment system is to be installed. Should any condition be found unsuitable, no work shall be done until the unsatisfactory conditions have been corrected and are acceptable to the Installer. Proceeding with work will imply acceptance of the conditions by the Installer.

3.2 INSTALLATION

A. Assemble and install the water treatment system in accordance with the manufacturer's instructions and recommendations, complete and ready to use.

B. Coordinate installation of the connections to the chilled water systems as required and in accordance with the construction schedule to minimize air conditioning outages.

C. The water treatment system shall be active from start-up of equipment. Contractor shall ensure a properly treated system upon start-up of the equipment and fill of the water system as indicated.

3.3 SERVICE REQUIREMENTS

A. The WTC shall visit the service sites to make an initial detailed chilled water and raw water analysis to establish the prescribed treatment program. Submit the program for approval.
   1. The initial service calls shall include establishment of treatment dosages, bleed schedules, and interval to replenish chemicals for automatic feed system.
   2. The WTC shall submit report on the results of the initial water analysis and the prescribed water treatment program including findings and recommendations. These reports shall be submitted to the State within three (3) calendar days following the service call to each site.
   3. The WTC shall also submit supplemental monthly, semi-annual and other supplemental reports as required and shall initiate and document any changes required from the initial prescribed water treatment program and the one year maintenance service contract.

B. The WTC shall make service calls and water analysis/testing at intervals of a maximum of thirty (30) calendar days for condenser water and one hundred eighty (180) calendar days for chilled water or sooner if required or notified of concern. WTC shall notify the using agency's point of contact at least 7 days prior to conducting the service and upon completion of the service/testing. The WTC shall:
   1. Provide initial application of each material and shall continuously furnish specific treatment of the water as required.
   2. Investigate any unusual conditions pertaining to scale deposition as indicated by condenser operating data, corrosion and algae growths, and implement corrective action as required.
   3. Submit the results of the water analysis and the prescribe water treatment including findings and recommendations and service requirements performed in a report. This

report shall be submitted to the State within three (3) calendar days following the service call.

C. The WTC shall be totally responsible for a continuous water treatment program.
   1. WTC shall be available on-site during the performance of the cooling tower and condenser tube cleaning services and coordinate the inspection with the Contractor and the State. Only one (1) chiller per site can be down at any time.
   2. The WTC shall be totally responsible for the water treatment equipment and shall keep it functioning at its optimum through proper maintenance, repair or replacement as required. The water treatment system including piping and electrical components of the water treatment system and includes the maintenance tasks for the One Year Maintenance Service Contract in paragraph 3.05 below.

3.4 INSTRUCTION TO PERSONNEL

Instruct the operations personnel in the aspects of safety, operation and maintenance of the water treatment system. Provide field instructions as specified in Section 230300 - GENERAL MECHANICAL REQUIREMENTS. Upon completion of the work and at a time designated, the services of one or more qualified personnel shall be provided by the Contractor for a period of not less than four (4) hours to instruct the representatives of the State in the safety operation and maintenance of the water treatment system. These field instructions shall cover all the items contained in the bound instructions. Daily sessions shall be separated into small sessions as indicated in Section 230300 - GENERAL MECHANICAL REQUIREMENTS.

3.5 ONE YEAR MAINTENANCE SERVICE CONTRACT

A. In addition to the Guaranty on materials and workmanship noted in Paragraph 1.05 of this Section, the Installer shall provide a Maintenance Service Contract, countersigned by the General Contractor.

B. The maintenance service contract shall provide for all labor, chemicals, material, equipment and parts to service the water treatment system complete, on a periodic basis, so as to assure its proper operation and function as defined in this Section.

C. The Maintenance Service Contract shall extend for a period of one (1) year commencing after 30 consecutive days of trouble-free operation after the Project Acceptance Date or as authorized by the State, if earlier than the Project Acceptance Date. All costs for periodic maintenance services shall be included in the lump sum base bid price.

D. Following each service/inspection, furnish an inspection report to the user agency. All work done and all material furnished shall be subject to inspection and approval of the Project Manager to determine compliance with the requirements and intentions of the contract.

E. All maintenance work shall be performed between the hours of 7:30 a.m. to 4:00 p.m. on normal working days from Monday through Friday, excluding State holidays. The contractor shall schedule their visits and work with the user agency.

F. The maintenance contractor shall exercise caution during the progress of his maintenance and repair work to prevent damage to the ceilings and other building elements. The contractor shall restore the existing construction, damaged by his negligence, to its original condition at his own expense.

G. The Maintenance Contractor shall keep a separate log recording all maintenance calls to the project at his office. The log shall include as a minimum, the following information:
   1. Name of the person making the service call.
   2. Date of the service call.
   3. Time in and out from the project.
   4. Findings and work performed.

H. The Maintenance Service Contract does not include repairs resulting from vandalism, negligent use or misuse of the equipment.

I. Chilled Water Chemical Feed System shall be serviced semiannually at 6 months and 12 months as follows:
   1. Check chemical concentration and add chemicals as needed to keep the residual concentration in 800 to 1000 PPM range. Should recharging be required, it shall be performed within one week from discovery or notification along with a new report to be submitted immediately. All chemicals shall be provided by the WTC as required to maintain chemical residual concentrations.
   2. Certify that system has received semiannual service and report residual concentration and the amount of chemical used at each site.

J. Condenser Water Chemical Feed System shall be serviced monthly as follows:
   1. Check chemical feed pumps for proper operation and adjust or repair as required for normal operation.
   2. Check condition of chemical drums and containment system for leaks and repair/replace and refill as required.
   3. Check operations of automatic chemical controller system, sensor and piping for proper operation.
   4. Check for leaks and repair. Report items that were serviced, adjusted, repaired etc.
   5. Calibrate chemical feed as required by water analysis from test results. Indicate amount of each chemical used at each site. Record and analyze readings of raw and systems water samples to include but not be limited to: pH, conductivity (micro-mho), silica, alkalinity, calcium hardness, magnesium, chlorides, bio-organism counts, halogen levels if applicable and nitrite residuals.
   6. Log water meter readings for make-up and bleed at sites where available. Remove empty chemical containers and clean water treatment areas.
   7. Record set points and recommended ranges including (make-up and bleed water meter readings at locations where available) and quantities of each chemical used and remaining.
   8. Certify that system has received monthly service and report all discrepancies, adjustments, repairs or corrections performed.

END OF SECTION

SECTION 236410 - CENTRAL REFRIGERATION EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This section covers the furnishing, fabrication, delivery and installation of the ventilation system complete, including but not limited to the following area for Central Plant Modifications:
   1. Chillers
   2. Cooling Towers
   3. Pumps
   4. Heat Pump
   5. Electrical conduits, wiring and components pertaining to the monitoring and control system.
   6. Operation and maintenance instruction manuals.
   7. Manufacturer's literature, shop drawings and record drawings.
   8. Inspection, test and guarantee.

1.2 RELATED WORK SPECIFIED IN OTHER SECTIONS

A. Mechanical work as specified in SECTION 230311 - GENERAL MECHANICAL REQUIREMENTS unless specified otherwise in other sections of DIVISION 15 - MECHANICAL.

B. Concrete work specified in DIVISION 3 - CONCRETE.

C. Painting work specified in DIVISION 9 - FINISHES.

D. Electrical work specified in DIVISION 26 - ELECTRICAL.

E. Seismic restraints and vibration isolation specified in SECTION 220548 - MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL.

G. Mechanical insulation work specified in SECTION 230700 – MECHANICAL INSULATION.

H. Piping, fittings and accessories specified in SECTION 232113 – CHILLED WATER AND CONDENSER WATER PIPING.

I. Air conditioning and ventilation system controls specified in SECTION 230923 - DIRECT DIGITAL CONTROL SYSTEMS.

J. Testing, adjusting and balancing of industrial ventilation systems specified in SECTION 230593 – HVAC TESTING/ADJUSTING/BALANCING.

1.3 CODES, STANDARDS, REGULATIONS

A. Installation of all work in this Section shall be made in accordance with State Department of Health Regulations, National Fire Protection Association, and the Uniform Building Code.

B. All applicable codes, regulations and ordinances of public bodies having jurisdiction are considered a part of these specifications; all work installed and materials provided must comply with the current edition of such codes, regulations and ordinances.

C. Present to the State certificates of inspection and approval from proper authorities.

1.4 CONTRACT DRAWINGS

A. Contract drawings are essentially diagrammatic, indicating general layout and approximate locations toward establishing the scope for uniform estimating basis for all bidders. They are not intended to be detailed construction working drawings. Equipment, ductwork and piping arrangements shall fit into space allotted and shall allow adequate clearances for servicing and maintenance. Reasonable modifications to indicated locations and arrangement to suit job conditions shall not constitute basis for requesting additional funds from the State.

B. Capacities of all equipment and materials shall be not less than those indicated.

C. Nameplate: Each major component of equipment shall have the manufacturer's name, address, and catalog number on a plate securely attached to the item of equipment.

D. Verification of Dimensions: The Contractor shall be responsible for the coordination and proper relation of his work to the building structure and to the work of all trades. The Contractor shall visit the premises and thoroughly familiarize himself with all details of the work and working conditions, to verify all dimensions in the field, and to advise the State of any discrepancy before performing any work.

1.5 SUBMITTALS

A. Submit in accordance with SECTION 013300 – SUBMITTAL PROCEDURES and SECTION 230300 - GENERAL MECHANICAL REQUIREMENTS.

B. Shop Drawings: Submit shop drawings of plans, performance data and details showing locations

C. Product Data: Submit product data

D. Schedules:
1. Schedule of equipment listing name and addresses of manufacturers; manufacturer's local supplier's name, address and phone number; catalog numbers and trade names in accordance with SECTION 230300 - GENERAL MECHANICAL REQUIREMENTS.

2. Maintenance service contract and schedule.

E. Reports: Testing, adjusting and balancing of air and chilled water systems specified in SECTION 230593 – HVAC TESTING/ADJUSTING/BALANCING.

F. Certificates of Conformance or Compliance: Submit certificates of conformance for performance and characteristics specified, the listed standards and in accordance with SECTION 230300 - GENERAL MECHANICAL REQUIREMENTS.

G. As-Built Drawings: Submit drawings in accordance with SECTION 230300 - GENERAL MECHANICAL REQUIREMENTS.

H. Operations and Maintenance Manuals: Submit manuals in accordance with SECTION 230300 - GENERAL MECHANICAL REQUIREMENTS.

I. Guarantee and Certificate: Submit two year guarantee and certificate in accordance with SECTION 230300 - GENERAL MECHANICAL REQUIREMENTS.

1.6 OMISSIONS

It is the intent of the plans and specifications to provide a complete installation. Should there be omissions, the Contractor shall call the attention of the University to such omissions in fifteen (15) days advance of the date of bid opening so that the necessary corrections can be made.

1.7 SPARE-PARTS DATA

After approval of materials and equipment and 1 month prior to the date of beneficial occupancy, the Contractor shall furnish a complete list of parts and supplies, with current source of supply.

1.8 CHILLER MANUFACTURER'S REPRESENTATIVE AND SERVICE CAPABILITIES

A. Furnish the services of a Hawaii-based manufacturer's representative who is factory authorized and trained to perform the services specified. The manufacturer's representative shall furnish recommendations and shall be on-site to provide assistance on the following matters:
   1. Technical direction of the erection including disassembly and reassembly if required, alignment, testing, and dehydrating.
   2. Testing hermetic equipment under pressure for leaks, and evacuation and dehydration of machine to 35 degrees wet bulb or an absolute pressure of not over 0.204-inch of mercury.
   3. Charging equipment with refrigerant and oil.
   4. Starting equipment and furnish instruction as to its proper care, operation and maintenance.

1.9 COOLING TOWER MANUFACTURER'S REPRESENTATIVE AND SERVICE CAPABILITIES

A. Furnish the services of the manufacturer's representative who is factory authorized and trained to perform the services specified. The manufacturer's representative shall furnish recommendations and shall be on-site to provide assistance on the following matters:
   1. Erection, alignment and testing.

   2. Starting equipment and furnish instruction as to its proper care, operation, and maintenance.

   3. Design, fabrication, and delivery of materials to the project site, observing and providing technical direction during tower installation and assuring the proper operation of the tower during startup.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Air conditioning and ventilation equipment to be considered for bid purposes shall be from a manufacturer that has locally stocked spare parts, representation, and support of a factory authorized service organization within 500 miles of the site of installation and has serviced manufacturer's units of comparable type, size and capacity as those specified herein. The manufacturer must have other units of comparable type, size and capacity installed and operating satisfactorily in the State of Hawaii for a minimum of two (2) years prior to bid opening.

2.2 PACKAGED WATER CHILLER

A. Provide a complete, packaged water chiller, mounted on a single, welded-steel base. The chiller shall be ready for operation after connections to utilities and charging. Equipment shall operate within capacity range and speed recommended by the manufacturer. Furnish one (1) complete charge of lubricating oil in sealed containers in addition to that placed in system. Parts weighing 50 pounds or more which must be removed for inspection, cleaning, or repair; such as motors, gear boxes, casing tops, condenser, and cooler heads; shall have lifting eyes or lugs. The chiller components shall fit through the access doors into the machine room. The chiller may require disassembly prior to installation at the job site for installation into the building. Disassembly and re-assembly costs shall be the responsibility of the Contractor.

B. Water-Cooled Chiller: The chiller shall be factory-assembled, designed, tested, and rated in accordance with ARI 550. Ratings shall be certified by the chiller manufacturer in accordance with the current version of ARI 550 using either R-134a. Power input at full load shall not exceed the indicated kW/ton value on the drawings. All materials shall be compatible with the refrigerant selected, R-134a. All pressure vessels shall be ASME stamped to meet the State of Hawaii Boiler and Elevator Codes. Unit shall include a full economizer refrigerant cycle and electronic expansion valve or fixed orifice metering.
   1. Compressors: Provide each chiller with a single or multiple semi-hermetic twin screw compressor(s) specifically designed for the refrigerant proposed. Statically and dynamically balanced, either direct or gear driven by an electric motor. Each compressor shall be provided with a discharge shutoff valve, internal muffler and check valve..
   2. Condenser: Shell-and-tube construction, permitting tubes to be cleaned from each end by removing water box cover plates or head and minimum amount of water piping. Provide drain and vent connections in water boxes. Water piping connections shall be 150-lb. ANSI flanges or suitable for Victaulic fittings and coordinated with the system piping. Refrigerant side design pressure shall comply with ASHRAE 15. Water side design pressure shall not be less than 150 psig. Tubes shall be fabricated of smooth bore or internally enhanced without fins seamless copper tubing to decrease fouling and shall be individually replaceable and rolled or brazed into copper or steel tube sheets. Base performance on a water velocity not less than 3 fps (feet per second) nor more than 12 fps and a fouling factor of 0.00025. Condenser shall be tube bundle type with baffles and tube supports to provide uniform flow distribution and minimize vibration. Water side pressure drop shall not exceed the maximum indicated at the design flow. Refrigerant and water sides shall be factory tested for leaks.

C. Liquid Cooler (Evaporator): Shall be removable copper tube, bundle type constructed of seamless copper tubing rolled or brazed into copper or steel tube sheets with baffles and tube supports of copper; or liquid cooler shall be fabricated of seamless copper tubing, plain or with integral fins or enhanced tubes, individually replaceable and rolled or brazed into copper or steel tube sheets with tube supports of copper or steel plate. Refrigerant side design pressure shall comply with ASHRAE 15. Water side design pressure shall not be less than 150 psig. Provide drain and vent connections in water boxes. Water connections shall be 150-lb. ANSI flanges or suitable for Victaulic fittings and coordinated with the system piping. Liquid cooler feed control shall feed liquid cooler at all levels of capacity from 100 percent down to minimum required operating level. Provide baffles for uniform flow distribution. Base performance on a water side velocity not less than 3 fps nor more than 12 fps, and fouling factor of 0.00025. Water side pressure drop shall not exceed the maximum indicated at the design flow. Shell shall be formed from carbon steel plate and incorporate rupture disc in accordance with ASHRAE 15. Refrigerant and water sides shall be factory tested for leaks.

D. Insulation: Provide factory installed insulation for surfaces subject to sweating including the liquid cooler, suction line piping, water boxes, economizer, and cooling lines. Insulation shall be 3/4-inch thick foam insulation with maximum thermal conductivity of 0.28 Btu-in/hr/sq. ft./degrees F. After installation and initial start-up, provide additional field installed insulation on any surface observed to be sweating. Field installed insulation shall be painted to match adjacent insulation surfaces.

E. Controls, Control Panel, and Gauges: The chiller shall be controlled by a stand-alone Direct Digital Control (DDC) System. Provide an automatic, unit mounted, capacity-reduction microprocessor-based system for stable operation from 100 percent to at least 20 percent of full load capacity or lower. Provide modulating-type, chilled-water control with adjustable throttling range, a means of calibration, and a means of adjusting chilled water temperature control point. Provide adjustable chilled water reset control. Unit mounted chilled water and condenser water flow and temperature switches may be provided. Provide a variable time delay to prevent compressor restart whenever compressor is shut down by the operating controls. Provide an adjustable setpoint load limiter to minimize amperage draw. Provide controls to restart chiller automatically if power is interrupted for three seconds or less.

1. A dedicated chiller control panel is to be supplied with each chiller by the chiller manufacturer. The panel shall be microprocessor-based, with factory packaging and testing of all required control components for reliable equipment operation. The panel shall be removable if necessary to facilitate field installation of the chiller.
2. The chiller control panel shall provide control of chiller operation and monitoring of chiller modules, sensors, actuators, relays and switches. The panel shall be a complete system for stand-alone chiller control and includes controls to safely and efficiently operate the chiller.
3. Safeties: The chiller control panel shall monitor such safeties as motor starting and running time between compressor/motor starts, low chilled water temperature, low evaporator refrigerant temperature, high condenser refrigerant pressure, evaporator and condenser water flow status, low oil pressure, low oil temperature, high oil temperature, high motor winding temperatures, sensor faults, and proper operation of unit controls.
    a. The chiller control panel shall incorporate advanced motor protection to safeguard the motor throughout the starting and running cycles from the adverse affects of:
        (1) Loss of refrigerant charge.
        (2) Reverse rotation.
        (3) Low chilled fluid temperature.

(4) Low oil pressure (each compressor circuit).
(5) Ground current fault.
(6) Thermal overload.
(7) High pressure.
(8) Electrical overload.
(9). Loss of phase.
(10) Current imbalance.
(11) Loss of flowc.

4. The chiller control panel shall be capable of displaying system data in the following formats:
   a. English units
   b. Numerical data as whole numbers or one digit right of decimal
   c. English language
5. The chiller control panel is to be provided with a starts counter and running time counter.
6. The front of the chiller control panel shall be capable of displaying the following in clear language, without the use of codes, look-up tables, or gauges. However, gauges may also be provided in addition to the points displayed on the control panel:
   a. Compressor lockout.
   b. Loss of charge.
   c. Low fluid flow.
   d. Low oil pressure.
   e. Cooler freeze protection.
   f. High or low suction superheat.
   g. Thermistor malfunction.
   h. Entering and leaving-fluid temperature.
   i. Evaporator and condenser pressure.
   j. Electronic expansion valve positions.
   k. All set points.
   l. Time of day.

7. The chiller control panel shall provide evaporator freeze protection and low limit control. This control shall be used to avoid low evaporator refrigerant temperature trip-outs during critical periods of chiller operation. The control shall take progressively more aggressive load limiting action in response to the severity of the rate of change and the actual value of the evaporator refrigerant temperature. A clear language diagnostic message, reflecting the operating status, shall be automatically displayed at the front panel whenever this control is in effect, and if the condition exists for more than 20 minutes, a limit warning alarm relay shall energize to indicate that the condition has persisted.
8. The chiller control panel shall provide:
   a. Automatic circuit lead/lag.
   b. Capacity control based on leaving chilled fluid temperature and compensated by rate of change of return-fluid temperature with temperature set point accuracy to 0.1 ° F.
   c. Limiting the chilled fluid temperature pull-down rate at start-up to an adjustable range of 0.2° F to 2° F per minute to prevent excessive demand spikes at start-up.
   d. Seven-day time schedule.
   e. Leaving chilled fluid temperature reset from return fluid, outdoor-air temperature, space temperature, or 4 to 20 mA input.

f. Demand limit control with 2-stage control (0 to 100% each) or through 4 to 20 mA input (0 to 100%).
g. Chilled and condenser water pump start/stop control.
h. Dual chiller control for series chiller applications without addition of hardware modules or additional thermistors.
i. Dual chiller control for parallel flow applications use one additional sensor.
j. Amperage readout per compressor with %MTA (must trip amps) per compressor.

9. The chiller control panel shall be capable of receiving the leaving chilled water temperature set point in the form of a 4-20 mA or 2-10 vdc signal from a remote source such as an enhanced control panel.
10. The chiller control panel shall be capable of receiving the electrical current limit set point in the form of a 4-20 mA or 2-10 vdc signal from a remote source such as an enhanced control panel.
11. The chiller control panel shall be capable of providing variable interval timers for short cycling protection. The variable timers shall adjust to the critical chiller operating parameters and the time between successive attempted starts of the compressor motor. Fixed start-to-start short cycling protection timers are not acceptable.
12. The chiller control panel shall be capable of independently invoking password protection of the entire display and keypad, operator settings (e.g. chilled water set point), machine configuration settings, and service start-up settings.
13. In lieu of analog signals, digital signals may be used but all appurtenant equipment, hardware and software for conversion to analog signals to communicate with the EMCS shall be provided as required to meet the interface requirements with the EMCS system.

F. Chiller Interface: Provide chiller interface to allow communication between the chiller control panel and the new EMCS. Interface shall allow output of all chiller displays and diagnostics to the EMCS including, but not limited to:
1. Entering and leaving evaporator water temperature
2. Entering and leaving condenser water temperature
3. Chilled water set point and set point source
4. Electrical current limit set point and set point source
5. Current chiller operating mode

Chiller Translator/BACnet: As part of the Chiller Control package provided with the Chiller by the Chiller Manufacturer, provide a communications system that will allow a BACnet-based Direct Digital Control (DDC) system to access each Chiller's Microprocessor/Control Panel's arrray of point information (such as pressures, temperatures, status, runtimes, suction, Amps, KW, and others), without installing any duplicate sensors.

The BACnet Chiller translator will communicate to the DDC system bi-directionally, utilizing standard ASHRAE BACnet Protocol, and will allow full Monitoring and Reset control of the Chillers by the BACnet DDC system.

The Chiller Manufacturer is to provide all devices and accessories as necessary to accomplish this Chiller interface, such as complete list of all available Chiller Points, all BACnet Protocol Implementation Conformance Statements (PICS) files, any necessary Software, all necessary Passwords, Labor as needed, and all interface Hardware as necessary for complete and operational connection to the BACnet DDC System.

G. Electric Motors and Starters: Provide polyphase, induction electric motors conforming to NEMA MG-1. Provide starter as indicated on the contract drawings. Provide hermetic motors suitable for use with the indicated electrical power characteristics and the type of starter provided. Starter size shall meet the requirements of the chiller manufacturer and conform to all requirements of NEC. Provide Star-delta, closed-transition type motor starter conforming to NEMA ICS-1 and ICS-2, NEMA 1 enclosure or a reduced voltage solid state starter as recommended by the chiller manufacturer. The solid state starter shall use silicon controlled rectifiers to provide smooth acceleration without current transitions or transients. Solid state starters requiring chilled or condenser water for cooling are not acceptable. Provide phase failure, phase reversal, phase imbalance, over voltage and under voltage protection. Provide voltmeter and ammeter with indicating display for each phase, chiller instantaneous kilowatts and control transformer sized for control power load. Power factor correction capacitors in each chiller starter to correct power factor to at least 93.5% shall be provided by the chiller manufacturer.

H. Refrigerant and Oil Charges: Provide full initial charge of dehydrated refrigerant and lubricating oil.

2.3 COOLING TOWERS

A. General: Provide an induced draft, counterflow type, factory assembled, film fill, industrial duty, stainless steel cooling tower situated as shown on the plans. Total operating horsepower of all fans shall not exceed those listed on the mechanical equipment schedule.

B. Performance: The tower capacity shall meet the minimum capacities indicated and its thermal performance shall be certified by the Cooling Tower Institute (CTI) in accordance with CTI STD-201. Additionally, the cooling tower manufacturer shall guarantee the performance of the tower as installed according to the drawings. The tower sound level at 100 percent operating speed shall not exceed the sound criteria indicated.

C. Construction: Except where otherwise specified, all components of the cooling tower shall be fabricated of heavy-gauge, series 316 stainless steel.

D. Mechanical Equipment: Fans shall be propeller-type, aluminum alloy blades and aluminum or electro-galvanized hubs. Blades shall be individually adjustable. Fans shall be direct drive drive. Provide extended grease lines and fittings.

Motors shall be premium efficiency, TEFC, 1.15 service factor, variable torque, and specially insulated for cooling tower duty. Motor shall be inverter duty for operation with variable frequency drive. Motor nameplate horsepower shall not be exceeded at design operation. Provide a fan vibration limit switch in NEMA 4 enclosure to de-energize the motor if high vibration levels are sensed.

E. Fill, Louvers & Drift Eliminators: PVC; resistant to rot, decay and biological attack; formed, crossfluted bonded together for strength and durability in block format for easy removal and replacement; suitable for use as a working surface; self-extinguishing with flame spread rating of 5 per ASTM E84-81a; able to withstand continuous operating temperature of 130ºF; and fabricated, formed and installed by the manufacturer to ensure water breaks up into droplets.

Drift eliminators shall be PVC, triple-pass, and shall limit drift losses to no more than 0.001% of the design GPM flow rate.

F. Hot Water Distribution System: Provide a pressure distribution system:
   1. Pressure Distribution System: Evenly distribute water over the fill material with pressurized spray tree. Spray tree shall be constructed of schedule 40 PVC pipes and non-corrosive materials. Nozzles shall be non-clogging, ABS, threaded into branch piping. Maximum pressure at inlet shall be 2 psig

G. Casing, Fan Deck, & Fan Cylinder: The casing and fan deck shall be heavy-gauge type 316 stainless steel. The top of the fan cylinder shall be equipped with a conical, non-sagging, removable fan guard, fabricated of welded rods, and of stainless steel construction.

H. Access: An access door shall be located on both endwalls for entry into the cold water basin and fan plenum area. Access doors shall be operable from inside as well as outside the tower. Provide a complete internal working platform for service of all internal components. Provide intermediate access platform at cold water basin access, ladder to access top of tower, railing at top of tower and/or access platform if fan access is from the side of the cooling tower. All handrails and guardrails shall be galvanized steel, ladders shall be aluminum.

I. Cold Water Collection Basin: The cold water basin shall be heavy-gauge series 316 stainless steel and shall include the number and type of suction connections required to accommodate the outflow piping system shown on the contract documents. Suction connections shall be equipped with stainless steel debris screens. A factory installed, float operated, mechanical makeup valve shall be included. An overflow and drain connection shall be provided in each cell of the tower as indicated. The basin floor adjacent to the depressed section shall slope toward the depressed section to prevent build-up of silt under the fill area. Provide an equalizer connection for external piping to connect the sumps of the cooling towers.

J. Cooing Tower Warranty: The cooling tower shall include a five (5) year warranty on parts and workmanship on the entire unit including structure, casing, basins, decking, fan(s), motor, bearings, mechanical support, sheaves, bushings and belt.

2.4 CHILLED WATER AND CONDENSER WATER PUMPS

A. Chilled Water Pumps: Pump shall be single stage, end suction, centrifugal type, base mounted with steel base and drip lip, all assembled, direct connected with flexible coupling and electric motor, suitable for the intended service. Pump performance shall be as indicated. Suction and discharge connections shall be flanged. Impeller shall be enclosed, non-overloading, bronze, statically and dynamically balanced to eliminate vibration, shall be keyed to a corrosion-resisting 316 stainless steel shaft with 316 stainless steel impeller retaining bolt. The case shall be cast iron with bronze casing rings fitted with bronze wearing or sealing rings. Bearings shall be cartridge type, enabling the entire rotating element to be removed without disturbing alignment or exposing the bearings to dirt, water and other foreign matter. Pump shall be provided with mechanical seals and metal coupling guard. Motor enclosure type and service factor shall be as indicated, cast iron frame, high efficiency and have sufficient horsepower for the service required to prevent overloading throughout the entire pump curve. Provide flexible pump connections and isolation valves for priming, vent, drain, thermistors and pressure gauges.

B. Condenser Water Pumps: Similar to Chilled Water Pump.

C. See SECTION 230700 - MECHANICAL INSULATION for requirements for chilled water pump insulation.

2.5 HOT WATER AND CHILLED WATER CIRCULATION PUMP

A. Pump shall be single stage, end suction, centrifugal type, base mounted with steel base and drip lip, all assembled, direct connected with flexible coupling and electric motor, suitable for the intended service. Pump performance shall be as indicated. Suction and discharge connections shall be flanged. Impeller shall be enclosed, non-overloading, bronze, statically and dynamically balanced to eliminate vibration, shall be keyed to a corrosion-resisting 316 stainless steel shaft with 316 stainless steel impeller retaining bolt. The case shall be cast iron with bronze casing rings fitted with bronze wearing or sealing rings. Bearings shall be cartridge type, enabling the entire rotating element to be removed without disturbing alignment or exposing the bearings to dirt, water and other foreign matter. Pump shall be provided with mechanical seals and metal coupling guard. Motor enclosure type and service factor shall be as indicated, cast iron frame, high efficiency and have sufficient horsepower for the service required to prevent overloading throughout the entire pump curve. Provide flexible pump connections and isolation valves for priming, matching suction diffuser/strainer, vent, drain, thermistors and pressure gauges.

B. For hot water circulation pump, pump shall be similar to above except provide all bronze construction and materials suitable for domestic hot water service.

C. See Section 230700 - MECHANICAL INSULATION for requirements for pump insulation.

2.6 HEAT PUMP WATER HEATER

A. Provide a complete, packaged reciprocating screw or scroll R-134a compressor heat pump water heater mounted on a single, welded-steel base. Heat pump shall comply with the performance indicated on the equipment schedule. Equipment shall operate within capacity range and speed recommended by the manufacturer.

B. Water-to-Water Heat Pump Water Heater: Heat pump shall be factory-assembled, constructed in accordance with ANSI B9.1 safety code, NEC and applicable ASME code. All materials shall be compatible with R-134a. All pressure vessels shall be ASME stamped.
   1. Reciprocating or Scroll Compressors: Provide multiple, reciprocating hermetic compressors for high pressure refrigerant. Each compressor shall be equipped with an automatically reversible oil pump, suction and discharge shutoff valves, and oil sight glass. Compressors shall be factory mounted on spring vibration isolators and shall be factory equipped with an insert-type crankcase heater to control oil dilution during shutdown. Motors shall be suction gas cooled, thermally protected, with maximum speed of 1750 rpm. Reciprocating compressors shall be equipped with electric actuated suction cut-off cylinder unloaders. An anti-recycle device shall be provided to prevent rapid compressor short cycling (i.e. rapid starting and stopping).
   2. Condenser: Shell-and-tube or tube-in-tube construction. Water piping connections shall be 150-lb. ANSI flanges or suitable for Victaulic fittings and coordinated with the system piping. Tubes shall be double wall if heating domestic water and single wall if heating process water, fabricated of seamless copper tubing and shall be individually replaceable and rolled or brazed into copper or steel tube sheets. Each condenser shall be constructed to provide positive liquid subcooling. Condenser shall be provided with a pressure relief

valve, purge cock and liquid shutoff valve. Water side pressure drop shall not exceed the maximum indicated. Refrigerant and water sides shall be factory tested for leaks.

3. Screw Compressor: Provide multiple, semi-hermetic screw compressors for high pressure refrigerant. Each compressor shall be equipped with a discharge shutoff valve, internal muffler and check valve. Compressors shall be factory mounted on vibration isolators. Motors shall be thermally protected, with maximum speed of 1750 rpm. An anti-recycle device shall be provided to prevent rapid compressor short cycling (i.e. rapid starting and stopping).

C. Liquid Cooler (Evaporator): Shall be shell-and-tube type, fabricated of seamless copper tubing, individually replaceable and rolled or brazed into copper or steel tube sheets with tube supports of copper or steel plate. Cooler shall be tested and have removable heads. Water piping connections shall be 150-lb. ANSI flanges or suitable for Victaulic fittings and coordinated with the system piping. Water side pressure drop shall not exceed the maximum indicated at the design flow. Shell shall be formed from carbon steel plate. Refrigerant and water sides shall be factory tested for leaks.

D. Refrigeration System: Each refrigerant circuit shall include: hot gas muffler, moisture indicating sight glass, replaceable core filter drier, thermostatic expansion valve, and charging valve. Provide at least 2 refrigerant circuits.

E. Insulation: Provide factory installed insulation for surfaces subject to sweating, including the liquid cooler, suction line piping, water boxes and cooling lines. Insulation shall be 3/4-inch thick polyvinyl chloride (PVC) insulation with maximum thermal conductivity of 0.28 Btu-in/hr/sq. ft./degrees F. All damaged insulation as a result of disassembly and reassembly shall be repaired or replaced at no additional cost. After installation and initial start-up, provide additional field installed insulation on any surface observed to be sweating. Field installed insulation shall be painted to match adjacent insulation surfaces.

F. Controls, Control Panel, and Gauges: The heat pump shall be controlled by a stand-alone micro-processor based system. Provide an automatic, unit mounted, capacity-reduction microprocessor-based system with adjustable throttling range, a means of calibration, and a means of adjusting chilled-water and hot water temperature control setpoint. Provide a variable time delay to prevent compressor restart whenever compressor is shut down by the operating controls. Provide automatic lead/lag control of refrigerant circuits and pump down at beginning and end of every circuit cycle. Provide controls to restart heat pump automatically if power is interrupted for three seconds or less.

1. A dedicated heat pump control panel shall supplied by the heat pump manufacturer. The panel shall be microprocessor-based, with factory packaging and testing of all required control components for reliable equipment operation. The panel shall be removable if necessary to facilitate field installation of the heat pump.
2. The heat pump control panel shall provide control of heat pump operation and monitoring of heat pump modules, sensors, actuators, relays and switches. The panel shall be a complete system for stand-alone heat pump control and includes controls to safely and efficiently operate the heat pump.
3. The heat pump control panel shall include high and low pressure cutout switches for each refrigerant circuit, a manual reset low water temperature cutout switch, a multiple-step temperature controller and temperature control sequence switch. Unit capacity shall be controlled by sensing hot water storage tank temperature. The leaving chilled water temperature controller shall be a low limit device preventing the chilled water temperature from dropping below a pre-determined setpoint.

4. Circuit breakers shall be factory installed for each compressor and shall be calibrated manual reset and ambient insensitive. Breakers shall open all 3 phases should an overload occur on any phase. Provide protection from loss of phase condition and low voltage.
5. An oil pressure safety switch shall be mounted on each unit for each refrigerant circuit.
6. The control panel shall include individual compressor indicator lights, a start-stop button, control power fuse or circuit breaker, control power transformer, a manual switch to change starting sequence of compressors and a demand limit switch.
7. The control panel shall allow remote start/stop and capacity control from the EMCS (See Specification SECTION 230923 – DIRECT DIGITAL CONTROL SYSTEMS).
8. For heat pumps with single wall tube condensers, the control system shall include a low pressure switch to detect a refrigerant leak. Provide a normally open contact which closes upon detection of a refrigerant to allow the energizing of a bypass valve in the potable water line to the condenser and bypassing the water around the condenser. Detection of a refrigerant leak shall also energize a pilot light on the heat pump control panel and send an alarm to the EMCS.

2.7 VARIABLE FREQUENCY DRIVE

A. Variable frequency drive (VFD) shall consist of solid-state adjustable frequency controller (AFC) and performance-matched energy efficient motor matched by the controller manufacturer and matched to the requirements of the specified pumps and air handling units. Provide all accessories for a completely operational system to meet the requirements and sequence of operation specified herein. Provide Reliance VTAC VII V*S Drive, XE motor, bypass contactor complete with cabinet and accessories specified unless otherwise noted, Magnetek, Danfoss, ABB or approved equal.

B. The Adjustable Frequency Controller (AFC) shall be a fully digital Pulse Width Modulator (PWM) using very large scale integration techniques as well as surface-mount technology for increased reliability. The AFC shall use a 16-bit micro-processor with a 12-bit resolution to allow stepless motor control from 1% to 110% of maximum motor base speed.
1. All programmable settings shall be held in non-volatile memory and shall not be affected by power outages, brown-outs, power dips, etc. The AFC shall have initial programmable settings intact from the factory without the need for battery backup. The AFC shall not need to be programmed at the job site prior to running the motor but shall be ready to run a motor as soon as power connections are made.
2. Programming at the job site to accommodate specific local application requirements such as frequency avoidance and preset speeds shall be available to the user. Complete motor and drive package efficiency versus load and speed shall be submitted prior to purchase and coordinated with the requirements of the pumps and air handling units.
3. All high voltage components within the enclosure shall be isolated with steel or polycarbonate covers.
4. The AFC and options shall be UL Listed and CSA Certified. The AFC and options shall comply with the applicable requirements of the latest standards of ANSI, IEEE and the National Electric Code.
5. The AFC shall be functionally tested under motor load and then cycled. This assures that if the AFC is started up according to the instruction manual provided, the unit will run reliable.
6. The AFC shall have the following features:
    a. Remote start-stop.
    b. Speed selection.

c. Timed acceleration and deceleration.
d. Current limit and voltage limit.
e. 6-66 Hz controlled speed range.

7. The AFC shall include the following features:
   a. Operators control shall be mounted on the door of the wall mounted steel cabinet and consist of a membrane command center which allows manual stop/start, speed control, local/remote status indication, manual or automatic speed control selection, run/jog selection and forward reverse selection. In addition, the command center will serve as a means to configure controller parameters such as minimum speed, maximum speed, acceleration and deceleration times, volts/hertz ratio, torque boost, slip compensation, over frequency limit, frequency agreement, current limit, and job frequency. Potentiometers will not be allowed for these settings. The controller shall have an internal means of deactivating keypad parameter adjustments to eliminate unauthorized data entry. A slip compensation circuit for accurate 1% speed regulation without the need of a tachometer.
   b. Adjustable D-C braking that is programmable from the command center adjustable in both amplitude and duration.
   c. An electronic overload circuit designed to protect an A-C motor operated by the AFC output from extended overload operation on an inverse time basis.
   d. Automatic and manual torque boosts that are adjustable within the control to accelerate hard-to-start applications.
   e. An LED display mounted on the door of the cabinet that digitally indicates:
      (1) Frequency output
      (2) Voltage output
      (3) Current output
      (4) First fault indication
   f. The capability of starting into a rotating load without the need of a time delay upon a start command.
   g. Relay contacts for remote indication of drive fault and motor running for interwiring to another device.
   h. An automatic restart circuit which is adjustable by number of restart attempts and the interval between restarts.
   i. Three critical frequency avoidance bands, which can be programmed in the field, enable the controller to avoid resonate frequencies of the driven equipment. Each critical frequency avoidance band shall have a band width adjustable via keypad entry of up to 10 Hertz.
   j. Three programmable preset speeds which will force the AFC to preset speed upon a user contact closure. This feature shall be set digitally by entering data via the door mounted membrane command center.
   k. The AFC shall have the capability to ride through power dips up to 500 msec without a controller trip depending on load and operating conditions.
   l. Multiple volts/hertz patterns adjustable in one hertz increments from 30 hertz to maximum hertz for maximum flexibility and control.
   m. Jog speed selection.
   n. Two frequency agreement speeds adjustable in the field and interconnected to on-board dry relay contacts.
   o. An isolated electrical following capability and control interface shall enable the AFC to follow a 0-20 mA, 4-20 mA, 0-4 volt, 0-8 volt, or 0-10 volt DC grounded or ungrounded speed signal from an external source. In addition, the drive shall be able to follow a pulse train speed signal input.

p. For smooth acceleration and deceleration capabilities, the drive shall have a pre-programmed ramp curve which can be activated locally.
q. Two auxiliary selectable contacts (DPDT) which can be activated by two of the following with the actual setpoint adjustable:
(1) Zero speed.
(2) Reverse rotation.
(3) Output current.
(4) Output speed.
(5) Run.
(6) Line dip in excess of 15 msec.

8. The AFC shall include the following protective circuits and features:
a. Instantaneous Electronic Trip for the following faults:
(1) Motor current exceeds 150% for longer than one minute of controller maximum sine wave current rating.
(2) Output phase-to-phase short circuit condition.
(3) Total ground fault under any operating condition.
(4) High input line voltage.
(5) Low input line voltage.
(6) Loss of input phase.
(7) External fault. (This protective circuit shall permit wiring of remote normally close safety contact to shut down the drive.)
b. DV/DT and DI/DT protection for semiconductors.
c. All live power equipment shall be covered by protective shields to ensure the safety of operating personnel.
d. Metal oxide varistors.
9. The AFC shall have the following separate adjustments available:
a. Maximum frequency - 66 Hz.
b. Minimum frequency - 0 to 5 Hz.
c. Acceleration - 0.1 to 360 seconds standard.
d. Deceleration - 0.1 to 360 seconds as standard.
e. Volts/Hertz - Programmable.
f. Maximum load - 150% for one minute.
g. Current limit: 50% to 150% of sine wave current rating.
h. Regulation Frequency Stability Long Term - ±0.01% of base speed.
i. Slip Compensation - ½ to 1% speed regulation.
10. The AFC shall be designed and constructed to operate within the following service conditions:
a. Elevation: to 3,300 feet without derating.
b. Ambient Operating Temperature Range: 0 degrees C to 40 degrees C.
c. Atmosphere: Non-condensing relative humidity to 95%.
d. A-C Line Voltage Variation: -5% to +10%.
e. A-C Line Frequency Variation: ±2 Hz.

C. The energy efficient motor shall utilize premium materials and optimized design for energy efficient performance and minimum losses on adjustable frequency power. Motors shall have the following electrical design features:
1. Full Class F, non-hygroscopic insulation system evaluated in accordance with IEEE-117 classification tests.
2. Motors shall be rated with a minimum 1.15 service factor on sine wave power and electrical design shall not exceed the insulation allowable temperature rise at 1.0 service factor on adjustable frequency power.

3. Motor windings shall be of copper.
4. Motor rotor construction shall be die cast aluminum or fabricated copper or their respective alloys. Rotor on frames 213T and above shall be keyed to shaft and rotating assembly dynamically balanced to NEMA limits per MG1-12.05. Balance weights, if required, shall be secured to the rotor resistance ring or fan blades by rivets. Machine screws and nuts are prohibited.
5. The motor shall use an open bearing (non-shielded) positive lubrication system. The design of this positive lubrication system shall minimize contaminant entry into bearings and protect against over lubrication and corrosion and grease migration into motor.
6. All mounting hardware shall be hex head, high strength, SAE Grade 5, zinc plated for corrosion protection. Screwdriver slot fasteners are prohibited.
7. TEFC motors with external cooling fans shall have fan covers with openings meeting the "guarded" definition of NEMA.
8. TEFC motors shall have provision for drainage of condensation at low points of the enclosure.
9. Each completed and assembled motor shall receive a routine factory test per NEMA standards. Test shall include winding resistance, no load current and power, high-potential test and mechanical vibration check.

D. Manual Bypass Transfer Switch:
1. Provide a full voltage, 3 contactor, motor transfer switch to directly switch en the AFC output and the incoming power line. This switch is mechanically interlocked between the AFC and the Bypass modes of operation. It is a motor horsepower rated switch which is UL listed as a manual motor starter without the requirement for a separate magnetic bypass motor starter.
2. Provide a main incoming disconnect circuit breaker (MCB) with a through-the-door handle, which is interlocked with the bypass cabinet door. This thermal magnetic circuit breaker will provide short circuit protection for motor while operating in the Bypass mode in accordance with the requirements of the National Electrical Code (NEC). Provide complete with the through-the-door handle to meet the National Electrical Code requirements for a lockable means of disconnect. This disconnect will remove all power from both control cabinets and the motor in all operating modes.
3. To meet the requirements of the National Electrical Code for motor thermal or current protection, a thermal overload relay (OL), sized for the motor nameplate full load amps (FLA) or the AFC “Sine Wave Amp” rating, whichever is lower, shall be provided.
4. Provide a complete manual bypass switch and AFC shall be mounted in a common cabinet within the MCC, NEMA 1, ventilated with 3% input line reactors and appurtenances.

E. Provide 3% integral AC input line reactors sized and selected by the VFD manufacturers.

F. VFD Interface: Provide VFD interface to allow communication between the VFD and the new DDC system. Interface shall allow output of all VFD displays and diagnostics to the DDC system.

VFD Translator/BACnet: Provide a communications system that will allow a BACnet-based Direct Digital Control (DDC) system to access each VFD’s microprocessor/control panel’s arrray of point information without installing any duplicate sensors.

The BACnet translator will communicate to the DDC system bi-directionally, utilizing standard ASHRAE BACnet Protocol, and will allow full monitoring and reset control of the chillers by the BACnet DDC system.

The VFD manufacturer is to provide all devices and accessories as necessary to accomplish this interface, such as complete list of all available points, all BACnet Protocol Implementation Conformance Statements (PICS) files, any necessary software, all necessary passwords, labor as needed, and all interface hardware as necessary for complete and operational connection to the BACnet DDC System.

2.8 MOTORS

A. Provide premium efficiency type motors designed for the supply voltages made available for this portion of the work, and with the following attributes:
   1. Sized to develop the required brake horsepower and to operate satisfactorily with a voltage variation of plus or minus 10 percent;
   2. Conforming to NEMA motor standards;
   3. Dynamically balanced, and held to commercial tolerance;
   4. Selected so that, when ambient temperature reaches 120 degrees F for a period of two hours or more, the motor will operate satisfactorily without failure.
   5. With squirrel-cage type drip-proof enclosure, unless otherwise indicated, constant speed, across-the-line normal starting torque designed for quiet operation;
   6. Each motor of ample size to operate its unit at proper full load and speed continuously, without heating in any part more than 40 degrees C above the temperature of the surrounding atmosphere.
   7. Where TEFC motors are indicated or specified, the cast iron frame type shall be provided.

B. Where motor is used with V-belt drive, equip with a sliding base and belt guard, and motor sheave.

C. Furnish motor starters for all equipment with electrical motors furnished under this Section. Unless factory installed, installation of starters and power wiring shall be provided by DIVISION 26 - ELECTRICAL.

2.9 MOTOR CONTROLLERS

A. NEMA ICS1 and NEMA ICS2. All controllers shall have thermal overload protection in each phase. Overload protective devices shall give adequate protection to the motor windings and be of the thermal inverse-time-limit type.

B. Provide full voltage, magnetic-type motor controllers with under voltage release and maintained contact push-button stations or switches unless otherwise indicated for all mechanical equipment furnished in DIVISION 23 - MECHANICAL. Provide each controller with a hand-off-automatic selector switch. Connections to the selector switch shall be such that only the normal automatic regulatory control devices will be bypassed when the switch is in the “hand” position. All safety control devices, such as low and high pressure cutouts, high temperature cutouts, and motor overload protective devices, shall be connected in the motor control circuit in both the “hand” and the “automatic” positions. Control circuit connections to any hand-off-automatic selector switch or to more than one automatic

regulatory control device shall be made in accordance with an indicated, or a manufacturer's approved, wiring diagram.

C. For each motor not in sight of the controller, provide a controller disconnecting means capable of being locked in the open position or a manually operated, nonfused switch in sight of the motor.

D. Enclosures shall be NEMA Type 1 for indoor locations and NEMA Type 4X, non-metallic for outdoor locations.

E. Provide each with a “hand-off-auto” switch, overload reset button, and indicating lights mounted on the hinged front cover with door interlock and manual defeater mechanism. Provide indicating lights (green for “Running” and red for “Overload”), phase failure and reversal relay, auxiliary contacts for contactors (1-N.O. and 1-N.C. unless noted otherwise), engraved plastic nameplates (“AHU-A1, B1, C1, C2 and E1”, etc.), control transformer, and fuses.

2.10 SPECIAL WIRING

A. All factory assembled, package type equipment shall be provided with integral control panel to which all motors in each unit shall be factory wired. Control panel shall contain all relays, starters, and other control devices, all arranged so as to be accessible for maintenance, testing, and inspection. Control panel on each unit shall contain control transformer installed so that all control circuits extending to remote control devices, thermostats, etc., will be 120 volts maximum.

B. All field installed control wiring not shown and required for the control of the air conditioning system from the packaged equipment including connections to other equipment (e.g. pump starters to motors) and to special field mounted safety control or apparatus (e.g. pipe mounted flow switches) shall be included under this Section. Field installed control wiring from the packaged equipment to/from the direct digital control system shall be included in the scope of SECTION 230923 - DIRECT DIGITAL CONTROL SYSTEMS. Control wiring shall include both control power (i.e. 120 volts or less) and communication for control signals. All control wiring shall meet the requirements of the NEC and shall be installed in metal conduit throughout the buildings.

2.11 EXPANSION TANK AND ACCESSORIES

A. Expansion Tank: Bladder type, closed expansion tank with heavy duty removable butyl rubber bladder. ASME construction, built for 125 psig working pressure, provided with cocks, connection on top, 1-1/2-inch charging valve in top and 1-inch drain valve in bottom. Insulate tank with 1-1/2-inch thick cellular glass insulation. Finish insulation with ASJ vapor barrier.

B. Accessories: Relief valve, strainer, and pressure reducing valve with valved bypass in cold water makeup line to chilled water system. Provide compressed air charge to maintain proper liquid level in expansion tank.

C. Air Separator: Steel tank, 125 psig working pressure, conforming to the requirements of ASME Boiler and Pressure Vessel Code with ASME stamp, connections as indicated, with

support and stand. Insulate separator with 1-1/2-inch thick cellular glass insulation. Finish insulation with ASJ vapor barrier.

D. Reduced Pressure Backflow Preventer (RPBP): Provide as specified in SECTION 220000 – PLUMBING.

E. Pressure Reducing Valve (PRV): Provide as specified in SECTION 220000 – PLUMBING.

F. Cooling Tower Makeup Water and Bleed-off Submeter: Provide magnetic drive turbine meter with bronze outer case, stainless steel fasteners, high-impact resistant plastic register lens cover, center hand sweep, straight reading totalizing in gallons. Register shall be permanently hermetically sealed and driven be a ceramic magnet. Submeter shall be Board of Water Supply listed and approved. Provide Hersey MVR series or approved equal. Submeter shall be provided with transmitter and other provisions for electronic remote monitoring, recording of data and transmission of data to the EMCS system.

2.12 HEAT PUMP EXPANSION TANK AND ACCESSORIES

A. Expansion Tank: Bladder type, closed expansion tank with rigid polypropylene liner and heavy duty removable butyl rubber bladder. Built for 125 psig working pressure, provided with cocks, connection on top and charging fitting. Tank shall be suitable for potable water service. Insulate tank with 1-1/2-inch thick cellular glass insulation. Finish insulation with ASJ vapor barrier.

B. Air Separator: Brass body, 150 psig working pressure, conforming to the requirements of ASME Boiler and Pressure Vessel Code with ASME stamp, separate venting chamber with integral vent, connections as indicated. Air separator shall be suitable for potable water service. Insulate separator with 1-1/2-inch thick cellular glass insulation. Finish insulation with ASJ vapor barrier.

2.13 VIBRATION ISOLATION

A. Provide as specified in SECTION 220548 – MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL.

PART 3 - EXECUTION

3.1 COOPERATION WITH OTHER TRADES AND CONFLICT IN WORK

A. Contractor shall examine all drawings of proposed work and coordinate his work with other trades. Work conflicts shall be brought to attention of State and work rearranged or modified in accordance with his decision.

B. If changes in indicated locations or arrangements of work are required, they shall be made by Contractor without additional charge to the State provided that these changes were ordered before work is installed and no extra material or labor are required.

C. Should Contractor determine that extra material and labor will be required to accommodate any rearrangement, he shall first submit detailed estimate of cost for required changes and proceed with work only upon written authority of the State.

3.2 CUTTING AND PATCHING

A. Cut all holes necessary for installation of work under this Section.

B. Patching of all holes, etc., will be done under other sections of specification. Patch any holes cut unnecessarily.

3.3 EQUIPMENT INSTALLATION

A. Equipment shall be installed as indicated and in accordance with manufacturer's recommendations and instructions.

B. All necessary supports shall be provided for equipment, appurtenances and duct as required. This work shall include any additional steel purlins, brackets, seismic restraints or supports.

C. Provide controls as indicated for proper operation of the equipment. Provide all necessary relays, contactors, enclosures and transformers to ensure proper system operation.

3.4 EQUIPMENT SUPPORT

A. Refer to drawings for type of construction from which equipment is to be supported. Structural metal supports shall be provided as indicated.

3.5 ACCESS TO EQUIPMENT

A. Install all control devices, specialties, valves and related items to provide easy access for operation, inspection, repair and maintenance. If these items are concealed behind walls or ceilings of non-removable type construction, provide access panels of proper size for easy access at no additional cost to the State.

3.6 VIBRATION ISOLATION

A. Provide vibration specified in SECTION 220548 – MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL.

B. Vibration transmission from all reciprocating and/or rotating equipment shall be effectively isolated, by use of vibration mountings or hangers. Mounting and hanger sizes shall be determined by the manufacturer to assure adequate deflection and vibration isolation, and shall be installed in accordance with manufacturer's recommendations to provide not less than 90 percent isolation efficiency.

C. All pipe connections to reciprocating and/or rotating equipment shall be made with flexible pipe connections.

3.7 EQUIPMENT IDENTIFICATION

A. Label equipment as specified in SECTION 230300 – GENERAL MECHANICAL REQUIREMENTS.

3.8 PAINTING

A. All ferrous metal shall be given one shop coat of red lead or other approved rust resisting paint. Where zinc coated metal is furnished, it shall not be shop primed unless specifically called for, but all abraded places and welds shall be touched up with Galvalloy or approved equal.

B. Pipe hangers, supports and other iron work in concealed spaces shall be thoroughly cleaned and painted with one coat of asphalt varnish. Finish painting of exposed items is specified in SECTION 09901 – PAINTING.

3.9 IDENTIFICATION OF PIPING

A. As specified in SECTION 230300 - GENERAL MECHANICAL REQUIREMENTS.

3.10 IDENTIFICATION OF VALVES

A. As specified in SECTION 230300 - GENERAL MECHANICAL REQUIREMENTS.

3.11 ADJUSTING AND CLEANING

A. Pipes shall be cleaned free of scale and thoroughly flushed of all foreign matter. Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided for all fans that are operated during construction and after all construction dirt has been removed, new filters shall be installed. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. All valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

3.12 TESTING, ADJUSTING AND BALANCING

A. Test, adjust and balance each piece of equipment as required to assure proper operation. See SECTION 230593 - HVAC TESTING/ADJUSTING/BALANCING.

3.13 CALIBRATION AND ADJUSTMENTS

A. After completion of the installation, perform final calibrations and adjustments of the equipment provided under this contract and supply services incidental to the proper performance of the unit control panels under warranty.

3.14 ACCEPTANCE PROCEDURE

A. Upon completion of the calibration, Contractor shall start-up the air conditioning system and perform all necessary testing and run diagnostic tests to ensure proper operation. Contractor shall be responsible for generating all software and entering all database necessary to perform the sequence of control and specified software routines. An acceptance test in the presence of the State shall be performed.

B. Provide operational acceptance tests. The tests shall be performed during a normal day of operation after the air conditioning system has been completely installed and made operable.

Results of the tests shall be indicated on the attached Operational Performance Test form and shall be part of the submittal for the testing and balancing report.

3.15 POSTED OPERATING INSTRUCTIONS

A. Furnish approved operation instructions for each principal item of equipment for the use of the operation and maintenance personnel. The operation instructions shall include wiring diagrams, control diagrams and control sequence for each principal item of equipment. Operating instruction shall be printed or engraved and shall be framed under glass or in approved laminated plastic and posted where directed by the State. Operating instruction shall be attached to or posted adjacent to each principal item of equipment including start-up, procedure in the event of equipment failure and other items of instruction as recommended by the manufacturer of each item of equipment. Operating instructions exposed to the weather shall be made of weather-resistant materials or shall be suitably enclosed to be weather protected. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

3.16 FIELD INSTRUCTION

A. See SECTION 230300 - GENERAL MECHANICAL REQUIREMENTS. Upon completion of the work and at a time designated, the services of one or more qualified personnel shall be provided by the Contractor for a period of not less than sixteen (16) hours to instruct the representatives of the State in the operation and maintenance of the air conditioning system. These field instructions shall cover all the items contained in the bound instructions.

3.17 ONE YEAR MAINTENANCE SERVICE CONTRACT

A. Shall be provided as specified in SECTION 230300 - GENERAL MECHANICAL REQUIREMENTS.

3.18 OPERATION AND MAINTENANCE MANUAL

A. Provide hard bound copies of the Operating and Maintenance Manual on all equipment and the system as a whole. Provide manuals in accordance with the requirements of SECTION 230300 - GENERAL MECHANICAL REQUIREMENTS.

3.19 SCHEDULE OF MAINTENANCE SERVICE

A. Shall be provided as specified in SECTION 230300 - GENERAL MECHANICAL REQUIREMENTS.

END OF SECTION